SER. II, VOL. 20 *March 1958* NO. 5

# TRANSACTIONS
## OF
# THE NEW YORK ACADEMY OF SCIENCES

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*Transactions of The New York Academy of Sciences*, Series II, Volume 20, No. 5, March 1958.

Entered as second-class matter December 28, 1954, at the post office at New York, N. Y., under the act of August 24, 1912. This publication is distributed to members and is published monthly from November to June, inclusive, by The New York Academy of Sciences, 2 East Sixty-third Street, New York 21, N. Y.

*Executive Director:* EUNICE THOMAS MINER

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V. 20
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# ORGANIC SEMICONDUCTORS*

By John J. Bohrer

*International Resistance Company, Philadelphia, Pa.*

## *Introduction*

In general, organic molecules are incapable of conducting current by the flow of electrons. In fact, major quantities of many organic compounds and polymers are used industrially because of their excellent insulating and dielectric properties. However, in the past ten years a considerable amount of attention has been given to the study of certain types of organic structures that appear to show conducting or semiconducting properties. Photoconductivity was observed in many dyestuffs[1] and in dyed gelatin films[2] as early as 1946. Chynoweth and Schneider[3,4] studied the photoconductivity of anthracene and observed that pure crystals, when illuminated with the wave length of the fundamental adsorption band, became conductive, the carriers being positive holes that took part in the trapping process. In 1951 Eley *et al.*[5] made a rather extensive study of conductivity of metal-free phthalocyanine and other condensed ring structures, some of which are shown in FIGURE 1. In their study of these compounds it was observed that pressure had a marked influence on the conductivity. Such an effect has been observed also by Akamatsu and Inokuchi[6,7] in their studies of isodibenzanthrone. A summary of these data is shown in TABLE 1.

Typical values for some well-known semiconductors are shown in TABLE 2. The energies of activations are quite similar.

Winslow *et al.*[9-10] have extended the studies of semiconductivity in such compounds to polymer molecules modified to give highly conjugated systems. Pyrolyzed polydivinyl and polytrivinyl benzenes possessed resistivities of from $10^6$ to $10^{-2}$ ohm-cm. when the pyrolysis temperatures were 700° C. and 1000° C., respectively. At 1000° C. the composition of such polymers was greater than 99 per cent carbon and they had become quite crystalline. Similarly, the pyrolysis of polyvinylidene chloride at 394° C. and 450° C. led to compositions of $(C_5HCl)_n$ and $(C_{10}HCl)_n$ with resistivities of approximately $10^{12}$ ohm-cm. and $10^9$ ohm-cm. at room temperature and with activation energies of 13.1 kcal. and 8.2 kcal./mole, respectively. These compositions also appeared to be crystalline in nature. The X-ray evidence indicated formation of condensed rings.

*This paper, illustrated with lantern slides, was presented at a meeting of the Section on February 4, 1958.

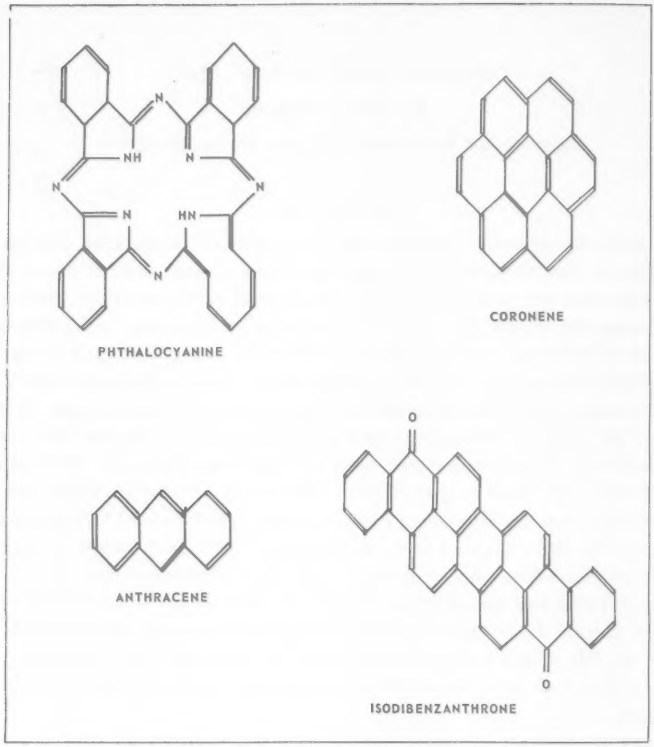



FIGURE 1. Semiconducting condensed ring structures.

Throughout all of this work two outstanding features of the materials make themselves evident: (1) all seem to be crystalline in nature, and (2) conjugated condensed aromatic rings appear to be involved.

Bayliss[11] has suggested, however, that conjugated polyenes should behave like metals or semiconductors. A possible method of preparation of polymer structures with a conjugated polyene backbone of the structure

$$- C = C - C = C - C = C - C = C -$$

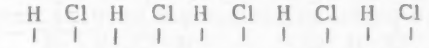
is by the dehydrohalogenation of polyvinylidene chloride $(-CH_2-CCl_2-)_n$. As previously stated, polyvinylidene chloride was used by Winslow *et al.*[10] to prepare semiconducting systems. The method entailed heating the samples well above 200° C. As these authors point out, such treatment tends to cause cross-linking or cyclization of the polymer chains.

TABLE 1

SEMICONDUCTIVE PROPERTIES OF SOME ORGANIC COMPOUNDS

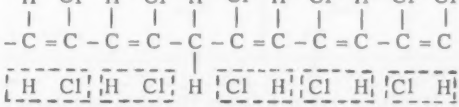
| *Compound* | *T* °C. | *E in kcal./mole* | $\log_{10} \rho o$ |
|---|---|---|---|
| Phthalocyanine | 100-500 | 27-29 | -2 to -4 |
| Phthalocyanine under pressure | | 9-13 | – |
| Phthalocyanine[8] | 10-100 | 10 | – |
| Coronene | 220-280 | 25 | 1.7 |
| Anthracene | 70-200 | 19 | 1.5 |
| Isodibenzanthrone | 50-250 | 18 | 1.4 |
| Isodibenzanthrone under pressure | 130-350 | 13 | – |

An alternative approach to the dehydrohalogenation process, while maintaining temperature well below 200° C., carried out in the laboratories of the International Resistance Company, was to react the polymer with a strong base. This was done in two ways: (1) using an organic base, morpholine; and (2) using an alcoholic NaOH solution as the dehydrohalogenation agent. By reacting the polyvinylidene chloride with these strong bases, it was hoped to prepare linear conjugated polymer chains of the structure



that would fulfill the requirements for conductivity.

Upon first consideration, there are a number of pitfalls to this approach. Random initiation of the dehydrohalogenation along the polymer chain could lead to a break in the regular double bond-single bond sequence as shown below:



It is known that the dechlorination of polyvinyl chloride by reaction with Zn to form cyclopane rings isolates about 13 per cent of the chlorine atoms,[12] as predicted by random initiation.

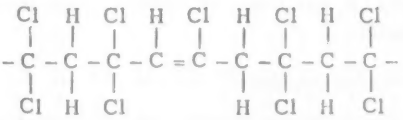
In the case of the dehydrohalogenation of polyvinylidene chloride, isolation of H (or of Cl) may not occur if the "zip" length of dehydrohalogenation is long compared to the length of the polymer chain.

TABLE 2

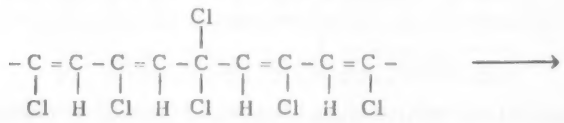
PROPERTIES OF SOME SEMICONDUCTING MATERIALS

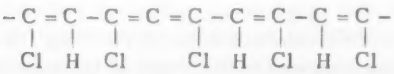
| *Material* | *ρ Ohm-cm.* | *Energy gap e.v.* |
|---|---|---|
| Cadmium telluride | $2 \times 10^4$ | 1.45 |
| Cadmium selenide | 0.05 | 1.77 |
| Zinc telluride | $1 \times 10^{11}$ | 2.1 |
| Cadmium sulfide | $1 \times 10^{13}$ | 2.4 |
| Zinc sulfide | | 2.6 |
| Aluminum phosphide | | 3.0 |
| Zinc oxide | 5.0 | 3.2 |
| Silicon carbide | | 3.5 |
| Zinc sulfide | $4.5 \times 10^9$ | 3.7 |
| Titanium dioxide | | 3.7 |

The zip length can be defined as the number of HCl units eliminated in a sequence. Long zip lengths may occur very easily since, once the first HCl is removed, the Cl atom along the chain (as well as the H in the other direction) is then allylic in nature and extremely reactive, facilitating further removal



of HCl. Thus, if the rate of removal of HCl by base attack on a nonallylic is slow and the allylic removed is fast with a long zip length, breaks in the double bond-single bond sequence may be avoided. Furthermore if such breaks do occur, it may be possible to eliminate them by the formation of allene groups as shown below:





While it is true that the reactivity of a chlorine atom on a double-bonded carbon atom is low, this particular chlorine atom is also an allylic chlorine, with an inductive effect to enhance its reactivity.

### *Experimental*

A sample of polyvinylidene chloride was prepared from freshly distilled vinylidene chloride, b.p. 32.5° C.-33.0° C., using azobis-isobutyronitrile as a catalyst. The polymerization was carried out at 70° C. in sealed glass tubes under $N_2$. The polymer precipitated as it was formed. It was washed with methanol 5 times and dried at 30° C. *in vacuo*.

This polymer was then treated with morpholine (freshly distilled) in the following manner. 150 ml. of morpholine was placed in a flask fitted with a condenser and a side arm to admit a steady stream of $N_2$. The nitrogen was bubbled through the liquid for 15 min. At this point 7 gm. of polyvinylidene chloride suspended in 30 ml. of morpholine was added to the flask, and heat was applied with $N_2$ bubbling through the liquid. Even before refluxing started, a rather violent reaction occurred and the contents of the flask became quite dark in color. The system was refluxed for 6 hours at 166° C. The contents were filtered, and the resulting black polymer was washed with ethanol followed by water until free of chloride ion. It was dried overnight *in vacuo* at 30° C.

In an attempt to determine the structure of the compound so obtained, elemental analysis was obtained. The results are shown in TABLE 3.

TABLE 3

ANALYSIS OF $PVCl_2$-MORPHOLINE REACTION PRODUCT

| | *Per cent found, duplicate samples* | | *Avg.* |
|---|---|---|---|
| | *1* | *2* | |
| Carbon | 56.47 | 56.59 | 56.53 |
| Hydrogen | 5.01 | 5.14 | 5.08 |
| Nitrogen | 6.86 | 6.64 | 6.75 |
| Chlorine | 7.16 | 7.40 | 7.28 |
| Ash | 0.00 | 0.00 | 0.00 |
| Oxygen (by diff.) | — | — | 24.36 |

The elemental analysis obtained results in an empirical formula of approximately $C_{46}\ H_{50}\ Cl_2\ N_5\ O_{15}$ as an average polymer composition. This composition is obviously quite different from the linear conjugated structure proposed as the product of the dehydrohalogenation of polyvinylidene chloride. While many structures might be visualized, mere elemental analysis does not produce sufficient data to support any of them fully.

An infrared spectrum was taken, using a KBr pellet in which was dispersed the black powder obtained in the dehydrohalogenation. This spectrum is shown in FIGURE 2, together with curves for polyvinylidene chloride and morpholine for comparison. The most notable feature of these curves is the complete loss of the characteristics of the polyvinylidene chloride curve after the reaction with morpholine has taken place. The presence of OH groups was indicated by an intense band at

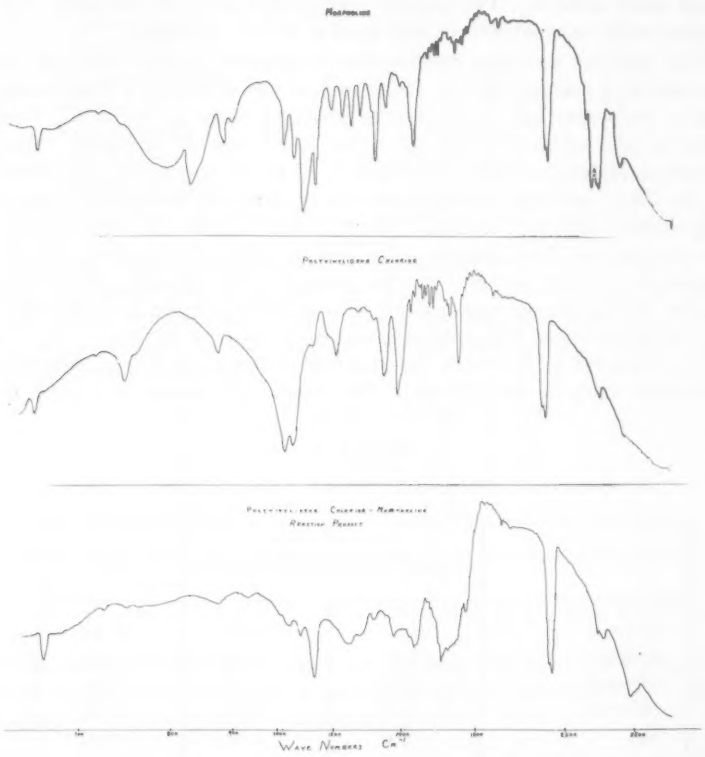


FIGURE 2. I-R spectra of morpholine, polyvinylidene chloride and their reaction product.

3380 cm.$^{-1}$ Two bands at 2930 and 2860 cm.$^{-1}$, due to C-H bonds, were comparatively weak. A deep band at 1695 cm.$^{-1}$ probably belongs to a C=O double bond. It is joined, by a broad absorption region, to a very intense band at 1108 cm.$^{-1}$, which also appears in morpholine, probably due to the C-O-C linkage.

The C≡C triple bond seems to be absent, as no band appeared in the region of 2100-2200 cm.$^{-1}$, where this bond generally absorbs. The broad adsorption band in the area of C=C has shifted to the longer wave length, as one might expect from either oxidation or long conjugated chains; this may also be inferred from the fact that the material itself is black.

Solubility and X-ray data were also obtained on this material. The black reaction product was completely insoluble in all solvents investigated; this could be taken as evidence of cross-linking, but does not necessitate the existence of crosslinks. The list of solvents investigated is shown in TABLE 4. The results of the X-ray examination, which indicated a complete absence of any crystal structure, are shown in FIGURE 3.

TABLE 4

SOLUBILITY DATA ON $PVCL_2$-MORPHOLINE REACTION PRODUCT

| INSOLUBLE IN | |
|---|---|
| Carbon tetrachloride | Butyl cellosolve |
| Chloroform | Perchloroethylene |
| Carbon disulfide | Tetrohydrofuran |
| Methyl ethyl ketone | Cyclohexanone |
| Dimethyl ketone | Benzene |
| Methyl alcohol | Dioxane |
| Ethyl alcohol | Toluene |
| Hexachlorobutadiene | |

During the course of examination of this material, it was observed that, if a powdered sample was held over the poles of a strong permanent magnet, some of the particles appeared to align themselves in the magnetic field.

In order to examine this property more carefully, a disc 3 cm. in diameter and about 0.1 cm. thick was formed by molding at 16,000 lb./sq. in. pressure and 200° C. There was no evidence of flow or melting under these conditions, but the finely divided powder was compressed into the shape of a disc with fairly good mechanical strength. A small hole was

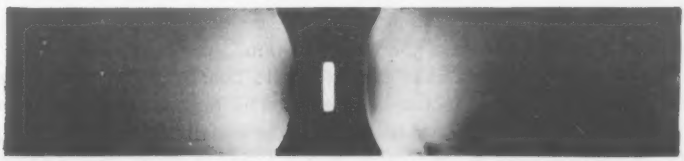


FIGURE 3. X-ray diagrams of polyvinylidene chloride-morpholine reaction product.

drilled close to the edge of this disc and it was suspended by means of a fine thread in a magnetic field. When this was done, the disc aligned itself in such a manner that the least number of magnetic force lines were cut. Such behavior is quite typical of paramagnetic materials and was considered to be an indication of the presence in the sample of unpaired electrons, that is, free radicals.

In order to obtain more quantitative data about the magnetic properties of this material, magnetic susceptibility measurements were made. These measurements were made on a sample of material prepared by the interaction of a copolymer of vinylidene chloride (85 per cent) and vinyl chloride (15 per cent) with morpholine. The reaction proceeds in the same way as in the case of pure polyvinylidene chloride and morpholine, and the reaction product exhibited the same qualitative properties. This sample showed a mass susceptibility, $\chi$, of $+1.56 \times 10^{-6}$ C.G.S. units. The mass susceptibility is related to the magnet dipole movement by

$$\mu \text{ eff. (in Bohr magnetrons)} = 2.84 \sqrt{\chi \cdot \text{mol. wt.} \cdot T} \qquad (1)$$

where $T$ is the absolute temperature.[13] A value for the molecular weight can be derived from the empirical formula obtained from the analytical data, since this formula would represent a repeating unit in the polymer chain. The analysis of the particular product under study is given in TABLE 5. This analysis results in an empirical formula of $C_{13}H_{15}NClO_3$ with a molecular weight of 268. Correction of the mass susceptibility for the atomic paramagnetic and diamagnetic contributions, utilizing the formula above, results in $\chi_{\text{mol.}}$ of $583 \times 10^{-6}$. Substituting in EQUATION 1, we obtain

$$\mu \text{ eff.} = 2.84 \sqrt{583 \times 300 \times 10^{-6}}$$

$$= 1.19 \quad \text{Bohr magnetrons}$$

This may be converted into the number of odd electrons by the relationship

$$\mu \text{ eff.} = \sqrt{n\,(n+2)}$$

$$n = 0.5 \qquad (2)$$

or approximately 1 free electron for every 2 repeating units or 18 carbon atoms along the backbone of the polymer chain.

All these data do not make it possible to conclude that the polymer has a particular given structure. However, there are a number of features of the structure that can be surmised from these data. Primarily, the high ratio of carbon atoms to the total of H, N, Cl, and O atoms necessitates a high degree of unsaturation. That this unsaturation is conjugated is suggested by the strong red shift in the spectra. The fact that these materials

TABLE 5

ANALYSIS OF $PVCl_2$-PVCl-MORPHOLINE REACTION PRODUCT

| | *Per cent found, duplicate samples* | | *Avg.* |
|---|---|---|---|
| | *1* | *2* | |
| Carbon | 57.1 | 56.7 | 56.9 |
| Hydrogen | 5.5 | 5.1 | 5.3 |
| Nitrogen | 5.0 | 5.1 | 5.0 |
| Chlorine | 16.8 | 18.2 | 17.5 |
| Ash | 0.4 | 0.0 | 0.2 |
| Oxygen (by diff.) | — | — | 15.1 |

are paramagnetic shows the presence of free electrons. Furthermore, these free electrons are stable even at temperatures well above room temperature. This is additional evidence of the conjugated nature of the compounds, and it would indicate also that the atoms within the chain are coplanar, necessitating rigid chain structure. The system does not tend to form any long-range order between chains, however, as shown by the lack of any evidence of crystallinity.

In spite of the fact that the materials as prepared do not appear to be those predicted by a simple dehydrohalogenation, they do possess the properties that should lead to electrical conductivity. To evaluate this property, the sample obtained by the dehydrohalogenation of pure polyvinylidene chloride was used. To measure the resistivity of this material, a voltmeter-ammeter method was used. A power supply capable of delivering between 250 and 1200 volts was used with a DC microammeter with a sensitivity of 0.0001 $\mu$a. The sample of powdered material was placed between two polished brass electrodes using a glass tube as a retainer. It has been reported[5] that the resistivity of phthalocyanine was a function of pressure. A similar effect was found with the materials under study here. The data in TABLES 6 and 7 and FIGURE 4 show this effect.

TABLE 6

RESISTIVITY, $\rho$, VERSUS LOAD

Sample Area = 3.20 cm.$^2$; Sample Thickness = 0.10 cm.; 350 Volts DC, 27.0° C.

| *Load kg.* | $\rho$ *Ohm-cm.* |
|---|---|
| 0 (electrode only) | $1.4 \times 10^{13}$ |
| 20 | $9.3 \times 10^{12}$ |
| 40 | $8.0 \times 10^{12}$ |
| 60 | $7.0 \times 10^{12}$ |
| 0 (electrode only) | $1.4 \times 10^{13}$ |

TABLE 7

RESISTIVITY VERSUS LOAD

Sample Area = 3.20 cm.$^2$; Sample Thickness = 0.1 cm.;
350 Volts DC, 100° C.

| *Load kg.* | *ρ (Increasing load) ohm-cm.* | *ρ (Decreasing load) ohm-cm.* |
|---|---|---|
| 0 (electrode only) | $2.5 \times 10^{10}$ | $2.5 \times 10^{10}$ |
| 10 | $2.2 \times 10^{10}$ | $1.9 \times 10^{10}$ |
| 20 | $2.1 \times 10^{10}$ | $1.8 \times 10^{10}$ |
| 30 | $2.0 \times 10^{10}$ | $1.8 \times 10^{10}$ |
| 40 | $1.9 \times 10^{10}$ | $1.8 \times 10^{10}$ |
| 50 | $1.9 \times 10^{10}$ | $1.8 \times 10^{10}$ |
| 60 | $1.8 \times 10^{10}$ | |

The weight of the electrode was considered negligible. The area of the specimen was 3.20 sq. cm. and the thickness was 0.1 cm.

At room temperature there appears to be a rather marked effect of pressure; the resistivity reduced to one half its value at zero load when there was a pressure of about 19 kg./sq. cm. on the sample. The effect appears quite reversible. At 100° C. the effect was very much less marked than at 27° C. and, while the resistivity values at the intermediate pressure did not check one another up and down the curve, the sample did return to its original resistivity at zero load. It was observed that steadier readings from the microammeter were obtained when some load was on the electrode.

The effect of temperature on resistivity is shown in TABLE 8. These data are plotted in FIGURE 5 and appear to satisfy the equation

$$\rho = \rho_o \, e_{exp} E/RT \qquad (3)$$

for the effect of temperature on resistivity of semiconductors.

Using these data, a value for E of 20 kcal./mole equivalent to 0.87 e.v. and a value of -0.13 for $\log_{10} \rho$ o were obtained. We see that these values are very similar to those obtained for other semiconducting organic molecules.

Applied voltage also affected the resistivity as shown by the data in TABLE 9. This effect was also found to be quite reversible (FIGURE 6).

As mentioned previously, dehydrohalogenation also was accomplished by reaction with alcoholic NaOH. When a sample of the polyvinylidene chloride already described was treated with caustic solution, a reaction very similar to the one with morpholine took place. The reaction was carried out at room temperature and at the reflux temperature. The analyses of the products obtained are given in TABLE 10. These analyses lead

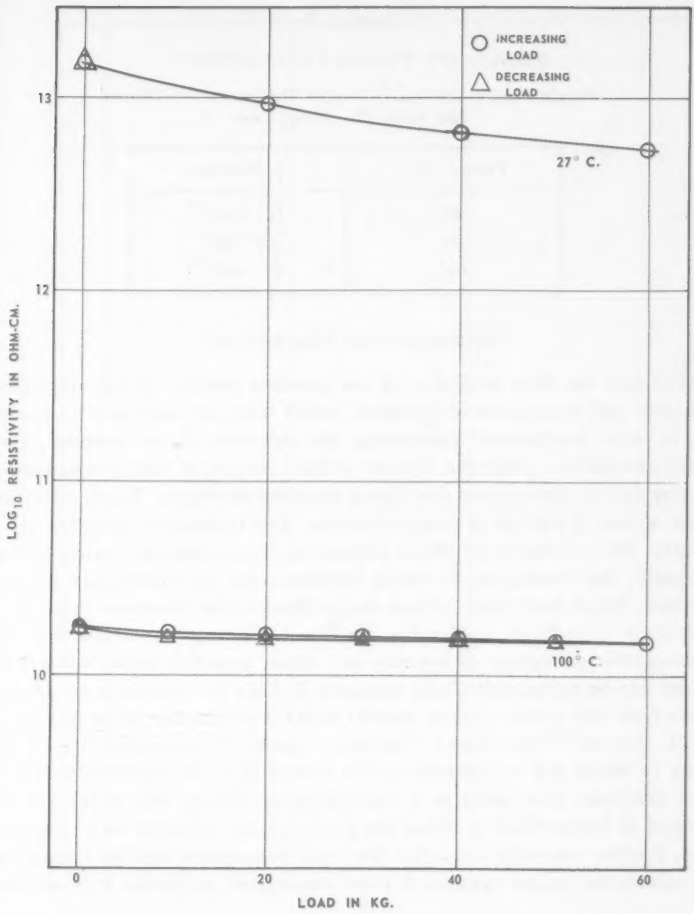



FIGURE 4. Load dependence of resistivity of polyvinylidene chloride-morpholine reaction product.

to empirical formulas of $C_{16}\ H_{11}\ Cl\ O_{2\text{-}3}$. It is interesting to note that, if the morpholine residues are extracted from the empirical formulas found in the reaction products from the morpholine-$PVCl_2$ reaction, very similar formulas are obtained. While electrical data on the alcoholic NaOH reaction product have not been obtained, all other data gathered on these products show that they are quite similar to the morpholine reaction products.

TABLE 8

RESISTIVITY VERSUS TEMPERATURE

Sample Area = 3.20 cm.$^2$; Sample Thickness = 0.10 cm.; 350 Volts DC, 20 kg. Load

| *Temp.* °C. | *ρ Ohm-cm.* |
|---|---|
| 27 | $0.9 \times 10^{13}$ |
| 71 | $3.3 \times 10^{11}$ |
| 102 | $2.1 \times 10^{10}$ |

## *Discussion and Conclusions*

Although the data available on the reaction product of polyvinylidene chloride and morpholine or alcoholic NaOH were not sufficient to enable us to draw conclusions concerning the structure of the material, they were adequate to place the product in the category of highly conjugated, noncrystalline substances containing unpaired electrons. These materials were shown to behave as semiconductors. The interesting question is, of course, the mechanism by which conduction takes place or, perhaps, more properly, the mechanism by which electrons are made available for conduction. There have been several suggestions in the literature that $\pi$ (Pz) electrons constitute conduction electrons. Pauling[14] showed that the diamagnetic anisotropy of benzene and other aromatic hydrocarbon molecules can be calculated if one assumes that the Pz electrons are free to move from one carbon atom to another under the influence of an impressed field. Bayliss[11] describes a "metallic" model of conjugated *trans* polyenes in which the $\pi$ electrons in the system have the characteristics of free electrons in a metal or a semiconductor. Using this model and the method of Sommerfield in which the electrons are regarded as an electron gas, Bayliss was able to predict the band frequencies and the intensities of adsorption in the spectra of *trans* conjugated polyenes. Furthermore,

TABLE 9

RESISTIVITY VERSUS APPLIED VOLTAGE

Twenty kg. Load at Room Temperature

| *Applied voltage* | *ρ Ohm-cm.* |
|---|---|
| 350 | $5.6 \times 10^{12}$ |
| 700 | $2.6 \times 10^{12}$ |
| 1000 | $1.6 \times 10^{12}$ |
| 1160 | $1.1 \times 10^{12}$ |

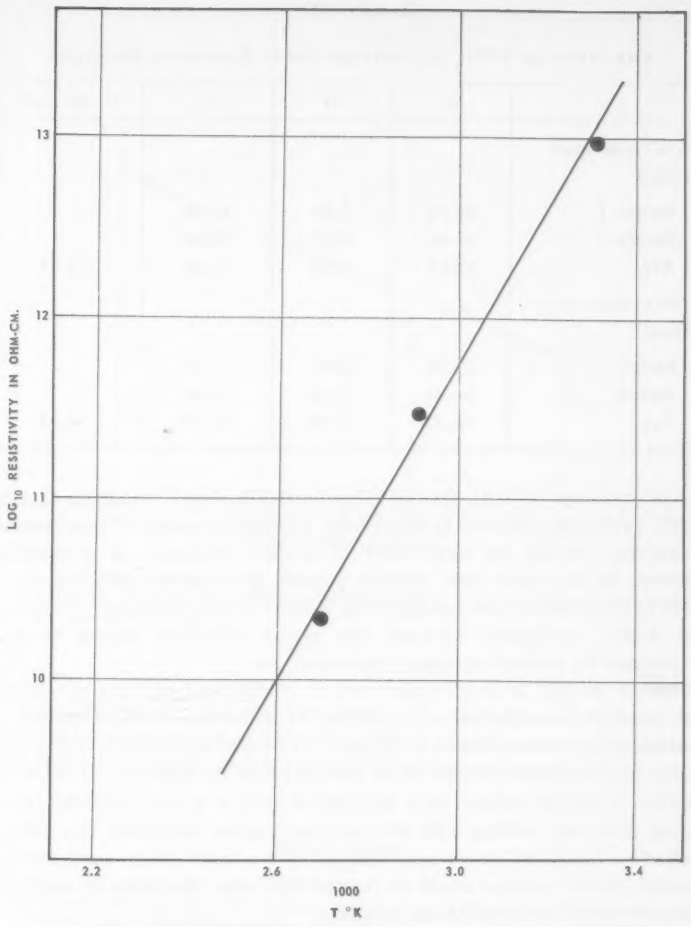



FIGURE 5. Temperature dependence of resistivity of polyvinylidene chloride-morpholine reaction product.

Bayliss states that, in an excited state, conjugated molecules have the partly filled energy levels required for metallic conductivity and that, if there were a mechanism for electron transfer between neighboring molecules, one should observe conductivity in bulk samples.

Chynoweth and Schneider,[3] in their study of the photoconductivity of anthracene, conclude from the behavior of the photocurrent at various applied fields and light intensities that conventional energy-band diagrams as used for inorganic systems could be applied to these conjugated

TABLE 10

ANALYSES OF $PVCL_2$-ALCOHOLIC NaOH REACTION PRODUCT

| | *C* | *H* | *Cl* | *O (By diff.)* |
|---|---|---|---|---|
| Room temperature Product | | | | |
| Sample 1 | 68.54 | 3.86 | 12.70 | |
| Sample 2 | 68.60 | 4.22 | 12.92 | |
| Avg. | 68.57 | 4.04 | 12.81 | 14.58 |
| Reflux temperature Product | | | | |
| Sample 1 | 67.51 | 3.92 | 12.69 | |
| Sample 2 | 66.34 | 3.65 | 12.60 | |
| Avg. | 66.93 | 3.78 | 12.65 | 16.64 |

organic systems as well. On the other hand, Winslow[10] suggests that for highly pyrolyzed polymer systems with continuous paths of conjugation, conduction occurs by movements of mobile electrons in overlapping orbitals. At the same time radicals provide the electron deficiencies or holes to contribute to the conductivity. There is good evidence[15,16] to show that highly conjugated systems can adsorb sufficient energy at room temperature to produce unpaired electrons.

Whether we talk of mobile electrons in overlapping orbitals or conduction bands may really be only a matter of semantics. If we consider an electron free to move about a system, no longer associated with a particular nucleus, the concept of an orbital loses its meaning. If we bring together $n$ carbon atoms, each associated with a $\pi$ (Pz) electron in an orbital that will overlap with its neighbors, these electrons may form a conduction band, which we may refer to as a $\pi$ band. Under such circumstances, these systems could be treated by Fermi statistics in much the same way metallic systems are treated.

While there is general agreement that $\pi$ (Pz) electrons provide the conduction electrons and that the holes are radical sites, a quantitative understanding of the mechanism of conduction in these organic systems is not available. It is quite possible, for example, that the conduction along a conjugated chain is metallic in nature, and that the effects measured are those associated with the conduction through defects in the conjugated or the transfer of electrons from chain to chain, molecule to molecule. More quantitative data from systems of well established structure are required before these questions can be answered.

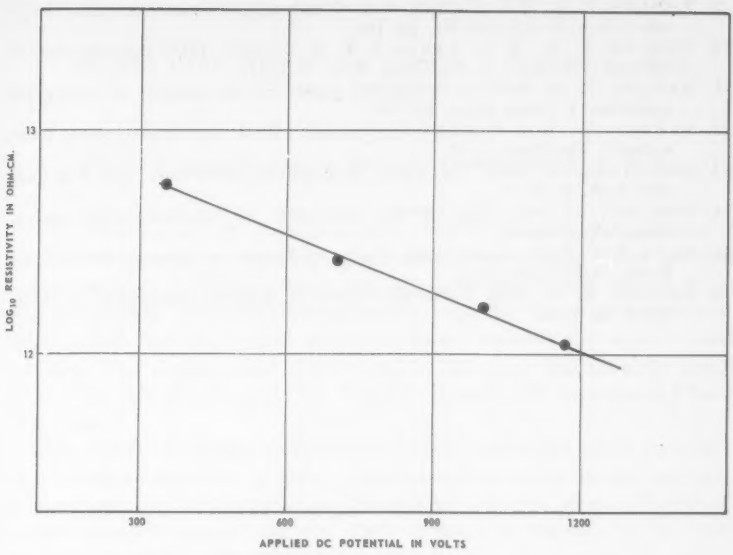



FIGURE 6. Voltage dependence of resistivity of polyvinylidene chloride-morpholine reaction product.

## *Acknowledgments*

I acknowledge the contributions made by J. Riseman during many discussions concerning this problem. In addition, the experimental assistance of V. Rolleri, W. Fishl, and J. Breakfield is acknowledged.

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THE NEW YORK ACADEMY OF SCIENCES

*SECTION OF BIOLOGY*

# VIRUSES THAT INFECT AND MULTIPLY IN BOTH PLANTS AND INSECTS*

*By* Karl Maramorosch

*The Rockefeller Institute for Medical Research, New York, N. Y.*

The evidence for the existence of a group of viruses that are able to multiply both in plants and animals and that require both hosts for their maintenance in nature has been well substantiated (Black, 1953a; Maramorosch, 1954). This evidence leaves no doubt that these viruses constitute a link between typical animal or insect viruses and typical plant viruses. The significance of this finding has been discussed in detail elsewhere (Maramorosch, 1955). Certain aspects will be mentioned here only briefly.

The ability of viruses to multiply in such diversified hosts as plants and animals indicates a strong resemblance to other living parasitic microorganisms. The infected plants may be regarded as only temporary repositories of viruses and the disseminators of viruses to the main mobile reservoirs – the arthropods.

The majority of biologically transmitted plant viruses have a fairly large host range among plant species, but a narrow one among arthropod vectors. This may have resulted from their long association with the animal host. It seems conceivable that these viruses were originally arthropod viruses. This hypothesis, expressed several years ago (Maramorosch, 1954), has since been accepted by a large number of workers (Andrewes, 1957; Bawden, 1957). The hypothesis could account for the harmlessness of the otherwise highly virulent plant viruses in respect to the susceptible arthropods. It is also supported by the finding of all degrees of dependence of these viruses in relation to their vectors. Several have the capacity to infect the progeny of viruliferous females, being thus maintained indefinitely in animals without the necessity of alternating plant hosts. Others rarely are transmitted transovarially, and still others must rely on the alternation between plants and arthropods because they no longer pass through the eggs of their arthropod hosts. A further step was discovered by Black (1953b) in viruses maintained for long periods in plants by grafting; two such viruses had lost the ability to infect their original arthropod hosts. In this respect viruses behave like other parasitic organisms, for instance, the malarian parasite.

*This paper, illustrated with lantern slides, was presented at a meeting of the Section on February 10, 1958.

Certain phases of this investigation were supported in part by Research Grant E-1537 from the National Institutes of Health, Public Health Service, Bethesda, Md.

Work on virus chemotherapy was supported, in part, by a Lalor Foundation Summer Research Fellowship and carried out at the Long Island Biological Laboratories, Cold Spring Harbor, N. Y.

Trager (personal communication) found that the avian malarian parasite *Plasmodium lophuriae* lost its capacity to produce the stage that infects mosquitoes after it had been maintained for sixteen years in ducks. There is no evidence for the loss of a stage of the virus in leafhopper-borne viruses, and the nature of the change may be explained more simply on the basis of a nutritional mutation, which also is in line with the assumption that these viruses are not mere chemicals, but parasitic organisms.

The existence of a group of viruses with dual hosts, plant and animal, provides a new tool for virus investigations. On the one hand the advantages of plant material can be employed: for instance, by using thousands of "identical twins" obtained from one individual by vegetative propagation. On the other hand, the arthropod host can provide a useful tool because its animal cells do not require wounding to permit the entrance of virus. Among the great advantages of the "dual hostship" is the ability to eliminate the plant host in certain tests with plant viruses as, for instance, in studies of chemotherapy (Maramorosch, 1958).

In addition to immediate practical advantages, some of which will be discussed below, the existence of viruses that are able to multiply both in plants and animals will eventually lead to the abandonment of the prevailing and still very convenient division of viruses into bacteriophages, animal, plant, and insect viruses; viruses will come to constitute a unified field of study.

### *Cytopathogenic Changes in an Insect Vector Chronically Infected with a Plant Virus*

Although leafhopper-borne viruses cause severe damage to their plant hosts, the infection of the arthropod seems not to interfere with its life functions. Infected insects are known to live as long and breed as freely as virus-free individuals.

In 1956 Virginia C. Littau, first at Columbia University, New York, N. Y., and later in our laboratory at the Rockefeller Institute, carried out a careful cytological study of various organs and tissues of virus-free and virus-infected leafhoppers. In aster leafhoppers, *Macrosteles fascifrons*, a pronounced abnormality was found in the appearance of fat body cells of certain, but not all, viruliferous individuals (Littau and Maramorosch, 1956). Since the histology of fat body cells may be affected by moulting, only adult animals were used. Insects were fixed in Carnoy's fluid and stained with azure B at *p*H 4.0. In nonviruliferous insects, nuclei of fat body cells tend to be round or to have smooth contours and the cytoplasm is generally homogenous, with numerous vacuoles of varied size enclosed within a definite cell membrane. In insects that acquire aster-yellows virus by feeding, nuclei of the fat body become stellate; basophilic cytoplasmic material becomes sparse and stringy, and apparently it is easily torn. Cell boundaries are not clearly seen.

Cytopathogenic changes induced by virus are seen in about 50 per cent of the males. The fat body tissue of females differs from that of the males. If any changes occur in cells, despite all the techniques so far employed, they have been obscured by the normal appearance of this tissue. It is of interest that the effects are not observed until some time after the completion of the extrinsic incubation period of the virus in the insect. Aster-yellows virus has a minimum incubation period of 9 days in its vector (Kunkel, 1926), and in the conditions of our tests the average length of incubation was 12 days at 25° C. It is only after the insects have had virus in their bodies for a period of from 18 to 28 days that the characteristic changes appear. It has been concluded, therefore, that the changes are the result of chronic virus infection. This was further substantiated by the finding that some insects that acquired virus by needle inoculation with juices of viruliferous insects, and not by feeding on diseased aster plants, also developed characteristic changes in their fat body cells after a prolonged period of time. Controls injected with juices of nonviruliferous insects were negative (Littau and Maramorosch, 1958). The over-all effect of the virus infection on the cytoplasm of fat body cells can be regarded as a loss of basophilic substance. Preliminary extraction experiments were made by V. C. Littau with hot trichloroacetic acid, and the results indicate that this basophilic substance is probably ribonucleic acid. The basophilic component is stringy and sparse, and large "empty" spaces suggest that the fixing fluid or some other cytological reagent may have extracted an abnormal metabolic storage product, which was present in large quantities in these cells as a consequence of virus infection.

The observations reported above demonstrate for the first time a cytological difference between viruliferous and nonviruliferous vectors of a plant virus. They provide evidence that this virus causes a chronic infection of the animal. It is believed that the cellular abnormalities are the result of a disease caused by the virus in the insect transmitter; if this assumption is correct, aster-yellows virus is the first virus known to cause a disease both of plants and of an animal. It is conceivable that the virus either multiplies in the fat body or that its multiplication elsewhere accounts for the effects observed. The present findings may also explain the mechanism of acquired immunity from infection by strains of aster-yellows virus in aster leafhoppers, discovered by Kunkel (1955, 1957), and also observed in corn leafhoppers infected with corn-stunt virus strains (Maramorosch, 1957).

### *The Developing of Insect Tissue Culture Techniques for Virus Study*

Attempts to grow insect tissues *in vitro* were first made by Goldschmidt in 1916. Trager (1935) cultivated ovarian tissues of *Bombyx mori* for

2 weeks in hanging-drop cultures and also demonstrated the multiplication of equine encephalitis virus in *in vitro* mosquito tissues (1938). With the exception of these experiments, until recently, little progress has been made in the field of insect tissue culture. In 1956 Maramorosch maintained tissues of aster leafhopper nymphs *in vitro* for 2 weeks and demonstrated the completion of the extrinsic incubation period of aster-yellows virus in these tissues (1956a). In 1956 Wyatt obtained encouraging results, maintaining ovarian tissues of *B. mori* for 3 weeks in roller tubes and observing growth for a period as long as 2 weeks. Loeb and Schneiderman (1956) maintained the wing epidermis of *Samia walkeri* pupae for 6 weeks, but obtained no growth. In 1956 T. Grace, in Australia, using hanging-drop cultures, grew cells from ovaries of fourth instar silkworm larvae. The cells underwent mitosis in hanging-drop preparations for 19 days and survived for 29 days in a medium consisting of Wyatt's solution (Wyatt, 1956) plus 10 components of the vitamin B complex, cholesterol, and extracts of endocrine and ovarian tissues.

In the beginning Grace's attempts to subculture the cells met with little success. Insect tissues do not seem to tolerate large amounts of protein and in this respect they differ markedly from vertebrate tissues. At first it was difficult to achieve continuous growth of insect tissues, and not more than one subculture survived. In Grace's experiments with *B. mori* it was never possible to reimplant the inoculum more than twice or to subculture the cells more than once.

In 1957 in our laboratory at the Rockefeller Institute, Grace succeeded in maintaining *in vitro* the ovarian tissue of the promethea moth *(Callosamia promethea)* for 303 days (Grace, in press). For these cultures Grace used diapausing pupae and a modified medium of Wyatt (1956). The mitoses and the increase in the cell population were used as criteria for growth. During the first 165 days the tissues not only survived but actively grew, which represents a big step toward the achievement of continuous growth of insect tissues. More recently Grace has also succeeded in subculturing insect cells. Explants from promethea moth ovaries were set up in hanging-drop cultures. After 48 hours cells moved out from the tissue. These cells did not remain attached to the explant, but either floated freely in the liquid medium or became attached to the cover glass. While the free-floating cells were round, those attached to the cover glass became spindle-shaped. After 72 hours numerous mitotic divisions could be seen, and the time from metaphase to complete cell division at 25° C. was about 20 min. Six days later the cells and pieces of tissues plus 6 fresh explants from ovaries were placed in an Erlenmeyer flask and shaken at 80 rpm for 4 days. Then all the explants and cells were placed in a roller tube and rotated at 1 revolution per 5 min. For the following 5 days cells migrated from the explants. After 6 days the tissues were subcultured. Ten days later a muscle contraction of the sheath around the

ovarioles was noticed. In the meantime cells migrated and increased in number by cell division. Ten days after the first, a second subculture was made. Seven days later a third subculture was made. The subculturing was continued, although in some instances no cell migration occurred. Between 100 and 105 days after the cultures were first set up, cells again began to migrate from the tissue mass. On the one hundred and fortieth day the culture was subcultured as previously and after 6 months cells still migrated and very strong contraction of the tissue occurred.

Grace's experiments indicate that long-term culture of insect tissues is now possible. The tissues continued to grow without prothoracic-gland hormone ("growth hormone"), and in 6 months 6 subcultures could be made. Although tissues can now be grown for long periods, it is not yet possible to grow dispersed cells continuously. It seems likely that the tissues became adapted to the medium during their long survival; this view is supported by the independence from growth hormone and by the long survival of cells that migrated from later cultures.

Further investigations are now aimed at cultivation of viruses in insect tissues in culture and at the growth of a monolayer of insect cells that would be susceptible to a plant virus. The results of preliminary experiments are very encouraging; an insect virus has already been grown in one of the insect tissues *in vitro* (Grace, 1958, in press).

### *A New Technique for the Study of Plant Viruses on a Cellular Level*

In 1955 Steward and in 1956 Nickell reported methods for the production of clones of plant material that can be maintained as single cells in continuous submerged cultivation. These methods differ from the one described by Muir *et al.* (1954), who isolated single plant cells from tissue cultures maintained on solid media and grew tissues from these cells. In Nickell's original article the new technique was discussed, using pole bean cells as an example. The manipulation of cells of higher plants in a way previously possible only with microorganisms and animal cells opened new possibilities for experimental virus work. In collaboration with Nickell an attempt was made to study one of the viruses with dual plant and arthropod hosts in suspensions of plant cells. The corn-stunt virus was chosen for this purpose because it is stable at 37° C. in plants and in vectors *in vivo*. Corn seedlings were grown from surface-sterilized seed of *Zea mays* in test tubes on agar. When the leaves reached approximately 15 cm. in length, the tip of a leaf was inoculated as shown in FIGURE 1. Infective *Dalbulus maidis* leafhoppers were confined to a leaf by means of a small celluloid cage (Maramorosch, 1951a) for one day. The protruding nonsterile portion of the leaf was cut off later. The seedlings were turned over to Nickell who, at the Phytochemistry Laboratory of Charles Pfizer & Co., Inc., Brooklyn, N. Y., isolated tissues from these

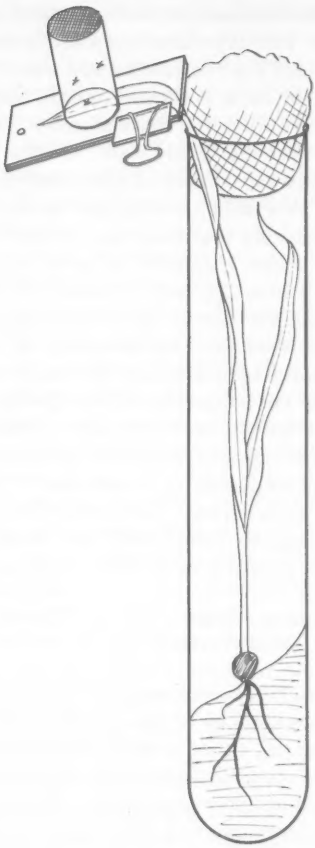

FIGURE 1. Inoculation of corn-stunt virus into a sterile corn seedling. Viruliferous insects, confined to an exposed portion of a leaf by means of a celluloid cage, infect the plant.

seedlings on solid medium. Subsequently he succeeded in growing the tissues under submerged conditions in Erlenmeyer flasks with rotary shaking at 230 rpm. After complete dissociation of the tissue clumps the cells continued to grow and several subcultures were made. Four months later a loopful of the single-cell suspension was returned to a solid medium and a multicellular tissue mass obtained. This tissue mass was tested in our laboratory at the Rockefeller Institute for the presence of virus. The cells were crushed in a mortar with a few drops of neutral buffered saline, centrifuged at 4500 rpm for 10 min., and small amounts of the supernatant fluid injected into 80 virus-free *D. maidis* from stock

culture. The mechanical inoculation followed the procedure described earlier for corn-stunt transmission (Maramorosch, 1951b). A group of 80 insects from the same stock was used as controls. The inoculated insects and controls were transferred to young corn seedlings as long as the insects lived. Transfers were made once every week, and individual insects were caged on individual seedlings. Controls were confined individually to individual seedlings during the first week, but later more than one were confined to a plant. This was done because the controls survived better than the injected insects; the number of test plants in the 2 groups was maintained equal by gradually reducing the number of plants exposed to controls. After 6 weeks, as many as 3 control leafhoppers were caged on each of 21 seedlings, while 21 surviving inoculated insects were tested on 21 plants. All exposed plants were maintained in a greenhouse for 90 days or longer. None of the controls transmitted corn stunt. Three of the injected insects became infective after an incubation period of considerable length; the first insect transmitted during the eighth week following inoculation, the other 2 during the ninth week. By that time the number of surviving inoculated insects was reduced to but 7 individuals. The results indicate that corn-stunt virus can be maintained in plant tissue culture and in submerged single-cell cultivation. The long incubation period in injected insects indicates that the concentration of virus in the inoculum was low.

Since it is now practicable to grow plant materials as individual cells, in effect treating them as microorganisms (Nickell, 1958, in press), it will be possible to isolate single cells from submerged cultures and to grow clones of these cells. For the first time this will permit a study of plant viruses on a cellular level. It appears desirable to test different virus-infected plant tissues in a similar manner, using viruses that are stable but multiply faster. In collaboration with Nickell such experiments are now in progress. It is hoped that the results will answer the following questions: does every cell of a given tissue in systemically infected plants carry virus? Do the nutritional requirements of infected and non-infected cells differ, and if so, in what manner? Can the rate of growth of infected cells exceed the rate of virus multiplication and can healthy cells be obtained from infected culture? The new technique lends itself to numerous other problems that until now were either difficult or impossible to solve.

### *Attempted Plant Virus Chemotherapy in in Vivo Insect Vectors*

Chemotherapy of diseases caused by numerous intracellular agents, with the exception of viruses, has already been accomplished. The human, animal, and plant diseases caused by viruses are not favorably altered by the administration of any known chemotherapeutic drug. The work of Tamm *et al.* (1954; Tamm, 1956) on the inhibitory action of a

variety of benzimidazole derivatives on human viruses led to the idea of using these compounds for plant virus chemotherapy. Ryzhkov in 1956 tried one of the benzimidazole derivatives against tobacco-mosaic virus. In such experiments one usually encounters as a main difficulty the phytotoxic, or stimulatory, effect on the plant host, which obscures the interpretation of results. The inability to introduce known amounts of chemical compounds into plants presents another complication. These common difficulties are also encountered in experiments in which plant tissue cultures (Melchers, 1958, in press), instead of intact plants or plant discs, are employed. Recently Nickell (1958, in press) discovered that plant cells respond to antibiotics in a manner similar to that of Gram-negative bacteria.

In order to avoid the above-mentioned problems, it became desirable to eliminate plant cells and plant material from tests of plant virus chemotherapy, and this was made possible by a new experimental approach. The new method made use of the alternate insect hosts of plant viruses. In *in vivo* tests various compounds were injected into viruliferous insects.

The results of preliminary tests showed that several antibacterial substances, including streptomycin, penicillin, and Aureomycin, had no effect on the plant viruses used. Also, using an improved insect-injection technique (Maramorosch, 1956b), the possible effect of 2,6-diaminopurine and 6-mercaptopurine on virus transmission was tested.* Transmission of aster yellows and curly-top virus by their respective vectors was not affected.

During these preliminary tests it was observed that insects can survive comparatively large doses of the compounds injected into their abdominal cavities.

A benzimidazole riboside, 5,6-dichloro-1-$\beta$-D-ribofuranosyl-benzimidazole (DRB)** was tested *in vivo* against 4 plant viruses in their respective vectors. Three of these viruses, those causing aster yellows (Maramorosch, 1952a), corn stunt (Maramorosch, 1952b), and wound-tumor disease (Black & Brakke, 1952) were earlier demonstrated to multiply in their leafhopper vectors. Multiplication of the fourth virus, curly top, has not been established. However, this virus was chosen because it has an incubation period in the insect vector of a few hours only, in contrast to the 9- to 14-day incubation periods of the other 3 viruses.

Approximately 0.001 ml. of a suspension of DRB, 5 mg./ml., was injected into each insect 1 or 2 days after virus acquisition, which was accomplished by allowing the insects to feed on diseased plants. An increase in the length of virus incubation or an inhibition in virus transmission was used as the criterion of inhibition of virus multiplication. The insects tolerated these comparatively large doses of DRB and,

*The purine analogues were made available through the generosity of L. G. Nickell.
**Synthesized by C. Shunk and K. Folkers of the Merck Research Laboratories, Rahway, N. J., and supplied by Igor Tamm of the Rockefeller Institute.

surprisingly, survived not only single injections, but also 2 injections given within only 6 hours; such double injections were made only in later tests with curly-top virus, when the first injection preceded and the second followed acquisition of virus.

Tests with wound-tumor virus in *Agallia constricta* demonstrated that DRB at the concentration used was inactive; furthermore, DRB was found inactive against corn-stunt virus in *D. maidis* and against curly-top virus in *Circulifer tenellus*. Tests with aster-yellows virus seemed to show no effect of DRB, but the evaluation of the latter results was difficult because of excessive heat during the beginning of the experiment. Heat affects adversely the transmission and multiplication of this virus in *M. fascifrons* (Kunkel, 1937, 1941); the incubation period in treated insects, as well as in the control insects, was excessively long.

Allfrey *et al.* (1957) showed that DRB inhibits ribonucleic acid synthesis, and Tamm *et al.* (1954) demonstrated that it inhibits influenza virus multiplication in tissue culture. Recently Kissman *et al.* (1957) presented evidence contradicting the work of Tamm *et al.*

The lack of antiviral chemotherapeutic effects *in vivo* in insect vectors of four different plant viruses used in our tests may be due to a number of factors. The highest concentration of DRB, introduced in one or two injections immediately preceding and shortly following virus acquisition, may have been inadequate to affect viral reproduction. Tamm found (personal communication) that amounts adequate to inhibit influenza virus in tissue culture were deleterious to living mice. In our tests, no deleterious effect on insect vectors was observed, a possible indication that the injected amounts were inadequate to influence nucleic acid synthesis. No further increase in the concentration of DRB was possible, because a 5-mg./ml. concentration formed a suspension instead of a solution and often clogged the fine micropipettes. Attempts to inject a 10-mg./ml. suspension failed. An increase in the volume of inoculum was not tolerated well by the tiny animals. Another possible explanation for the lack of virus inhibition could be that the four viruses do not contain RNA; the composition of these viruses is as yet unknown. DRB was reported to inhibit RNA synthesis, but not DNA synthesis. Bacterial and insect viruses, as far as tested, contain DNA; several plant viruses and two human viruses (polio and influenza) contain RNA. If the viruses with dual hosts (plants and insects) contain DNA, the lack of inhibition could be explained easily.

The reproduction of viruses is more intimately dependent on host cell metabolism than is the multiplication of the larger and more complex intracellular parasites. It is likely that synthesis of virus nucleic acid will eventually be inhibited on the nucleoside level. For many human and animal viruses the ideal chemotherapeutic agent may be one which, administered after diagnosis of infection, would satisfactorily modify the

course of the disease without affecting the build-up of immunity. With plant viruses there are two situations in which chemical control would be most desirable. Many economically important plants are reproduced vegetatively from virus-infected stock. Freeing such stock from virus infection would be of great importance. Certain plants, grown for many years and often very valuable, are normally subject to continued reinfection by insect vectors. It would be most helpful to find chemotherapeutic agents that would free infected plants from their virus diseases and prevent reinfection. The new technique of employing insect hosts of plant viruses for the screening of promising compounds may prove very valuable in such investigations.

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## *SECTION OF PSYCHOLOGY*

# OUTLINES OF A NEW THEORY OF EMOTION*

*By* Robert Plutchik

*Department of Psychology, Hofstra College, Hempstead, N. Y.*

In the past few years various authors have proposed a number of new theories of emotion. To the classical James-Lange and Cannon-Bard theories have been added the attitude theory by Nina Bull,[4,5] the activation theory developed by Lindsley[15] and Schlosberg,[23] the psychoanalytic theory formalized by Rapaport,[22] and Leeper's[14] motivational theory of emotion.

Both the James-Lange and attitude theories are concerned primarily with the sequence problem: does the feeling of an emotion precede or follow the bodily changes? James concluded that it follows, while Bull has suggested, and tried to support the theory with certain experiments using hypnosis,[3,18] that the feeling of an emotion is only associated with a complex preparatory motor attitude, which is "both involuntary and instinctive."

The Cannon-Bard theory has attempted to provide evidence for the existence of a particular neural integrating center in emotional expression. While many authors have critized this theory on various grounds,[1,15,17] the Lindsley activation theory is basically an extension of it. On the other hand, Schlosberg's concept of an activation theory[23] conceives of three dimensions as being necessary to describe emotional experience, an intensity or level of activation dimension, a dimension of pleasantness-unpleasantness, and a dimension called acceptance-rejection.

Rapaport's interpretation of psychoanalytic theory assumes that the basic dynamics of emotion are unconscious, and that emotions represent expressions of instinctual conflict. The theory eliminates the sequence problem by claiming that both the feeling of an emotion and the bodily process are manifestations of the same psychic process.

The motivational theory proposed by Leeper criticizes the prevalent concept of emotion as a disorganized disturbance of the organism and substitutes the idea that all emotions, anger as well as joy and love, act to "arouse, sustain, and direct activity," and thus are like organizing motives.

Rather than critically analyze each theory in turn, a number of general comments may be made. Each theory tends to deal only with a limited aspect of the many problems involved in the study of emotion. Thus, one

*A longer version of this paper, illustrated with lantern slides, was presented at a meeting of the Section on February 17, 1958.

deals with the sequence problem, another with the question of disorganization, a third with the intensity dimension, a fourth with the problem of conflict and unconscious dynamics, and a fifth with the problem of neural structures. Important as each question is individually, an answer to it can hardly qualify as a comprehensive theory of emotion. Such issues as the difference between acute and chronic emotions, the problem of repressed emotion, the nature of mixed emotion, the question of differences between emotions, the effect of learning on emotion, the problem of control of emotion – these and many other questions are left unanswered by all the theories described. Some of these theories have persisted in textbooks despite the existence of contradictory facts on relevant criticism. The probable reason for this, as Conant[7] has remarked, is that "A theory is never overthrown by contradictory facts; it is only overthrown by a better theory."

In a recent paper, I have attempted[21] to provide evidence for the view that some of the reasons for the many difficulties and disagreements in the study of emotion concern the following problems: since emotions may differ in intensity, different investigators may study a given emotion under different levels of arousal with quite different results; laboratory studies of transient emotions are dealing with a phenomenon qualitatively different from studies of the persistent emotions typical of clinical patients; mixed emotions have characteristics different from those of relatively pure emotions; averaging of individual data under standard conditions may produce misleading results because of the existence of subgroups with markedly different characteristics; introspective reports of emotional feeling cannot be an essential aspect of the definition of emotion, since many studies and theories use data obtained from animals, as well as from clinical patients who have repressed their emotions. In the light of these various problems it was suggested that a definition of emotion be such that it (1) does not require (although it may use) introspections, (2) can be applied to lower animals and patients with "unconscious" emotions, and (3) can be applied to mixed, pure, or varying intensities of emotion.

What this implies is the need for a concept of emotions as idealized states or "hypothetical constructs," in somewhat the same way that the physicist conceptualizes the point masses, freely falling bodies, and frictionless surfaces to which his laws, strictly speaking, apply. "Pure" or "hypothetical" emotions in this ideal sense may be defined by various properties that can be approached experimentally only by a series of successive approximations.

### *The Present Theory*

In trying to evaluate the adequacy of any theory, several important criteria should be considered: (1) that known observations or facts be

explained or accounted for; (2) that new observations be suggested; and (3) that observations that seem quite separate be shown to be related. Another aspect of theory construction is that the basic terms or ideas of a theory need not necessarily accord with common sense, as long as the experiences of common sense can ultimately be derived (or synthesized) from them. Neither atoms nor the fixations of psychoanalytic theory are observed directly, but can only be inferred, just as pure colors and pure elements can only be approximated more or less closely, and never completely obtained. It should be noted also that most theories tend to use analogy as a guide for their development. Another way of saying this is that a model is used as a basis for suggesting relationships that might not otherwise be obvious.

The theory of emotion presented here utilizes all these procedures. It attempts both an analysis and a synthesis of all the complex emotions of everyday life; it conceives of the units of analysis as hypothetical constructs; it uses the analogy of the color prism to guide its development.

It might be noted, parenthetically, that Wundt in 1910[6] and Schlosberg[23] more recently have used the color prism as a conceptual model for thinking about emotions, and that the concept of primary emotions and primary factors goes back at least half a century.[6]

### *Postulates of the Present Theory*

The parenthetical remarks made after each postulate are meant only to make them seem reasonable, not to "prove" them; as stated earlier, the theory's validity must be judged in terms of its ability to organize and integrate data.

(1) There is a small number of "pure" or "primary" emotions. This concept is consistent with many aspects of academic psychology, factor analysis, and psychoanalysis.

(2) All other emotions are mixed, that is, they can be synthesized by various combinations of the primary emotions. This is implied by factor analysis as well as psychoanalytic concepts.

(3) Primary emotions differ from each other both with regard to physiology and behavior. There is a growing body of literature that indicates that there are definite differences between such emotions as fear and anger, disgust and depression, and pleasure and resentment. Such differences have been reported by Ax,[2] Davis,[8] Funkenstein,[11] Wolff,[24] Bull and Gidro-Frank,[3] and Pasquarelli,[18] to name a few.

(4) Primary emotions are hypothetical constructs or ideal states whose properties can only be inferred from various kinds of evidence. This is based on the fact that most, if not all, the emotions of daily life are mixed, and that many problems of measurement are involved.

(5) Primary emotions can be conceptualized in terms of pairs of polar opposites. We cannot simultaneously be happy and sad or accepting and rejecting. Many emotion terms represent opposites, and factor analysis of temperamental characteristics usually produces bipolar factors.[12]

(6) Each emotion can exist in varying degrees of intensity, or levels of arousal. Duffy,[9] Schlosberg,[23] and Malmo[16] have provided experimental evidence for a level of activation dimension. Our language distinguishes between grief and sadness, terror and fear, and ecstasy and pleasure.

The next step in the development of the theory involves the organization of the postulates by use of a model or analogy. Choosing the color prism as the model meant that the primary emotions should be arranged around an "emotion circle," that there should be a gradation of emotions (in some sense) around the circle, and that the primaries be at least subjectively "pure," that is, unanalyzable on an introspective basis.

After considerable examination, I arrived at four pairs of primary emotions, each pair conceived as bipolar factors, and tentatively called by the following names: joy versus sadness, acceptance versus disgust, surprise versus expectancy, and fear versus anger.

These are arranged around a circle as shown in FIGURE 1. Opposite emotions on the circle are complementary, as are colors; that is, we cannot conceive of opposite emotions as existing simultaneously without conflict, confusion, neutralization, inhibition, or immobilization. The letter *C* at the center of the circle is designed to represent this idea. It

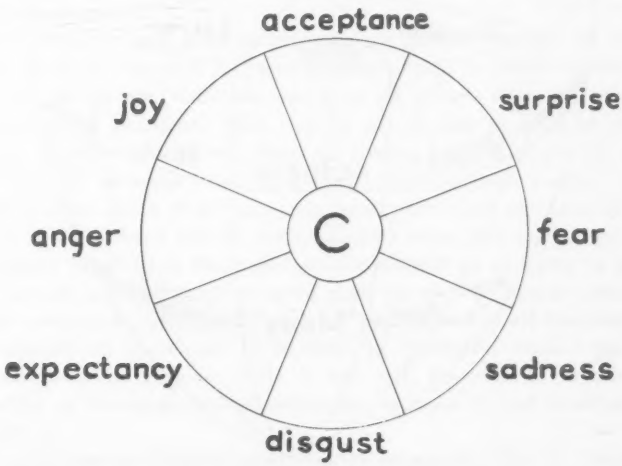


FIGURE 1. A cross section of the emotion solid.

may also be noted in FIGURE 1 that there is a certain reasonableness in the progression of primary emotions around the circle. Although joy is a unique emotion, it is expansive and excited as is anger (people feel good when they "blow off steam"), while both sorrow and fear are contracted. Surprise is related to startle, which is close to fear. Expectancy, set, or vigilance is an outwardly directed process, and thus belongs more closely to anger than fear and sorrow. The feeling tone associated with disgust is basically rejection, yet each primary emotion is unique in itself just as each primary color is unique.

There is some question, however, as to how best to name each primary emotion since, if the intensity or level of arousal dimension is considered, each primary emotion can exist in varying degrees. It is difficult to specify which particular term in our language for one emotion (for example, fear) should be set approximately equal in intensity to terms for other emotions. The one set of exceptions would be the terms describing the primary emotions when activated to their highest degree. We should then have ecstasy instead of joy, terror instead of fear, revulsion instead of disgust, and rage instead of anger. We may thus conceive of the model in three-dimensional terms roughly as half an orange with eight sections, as shown in FIGURE 2. If we imagine taking successive cross sections, we

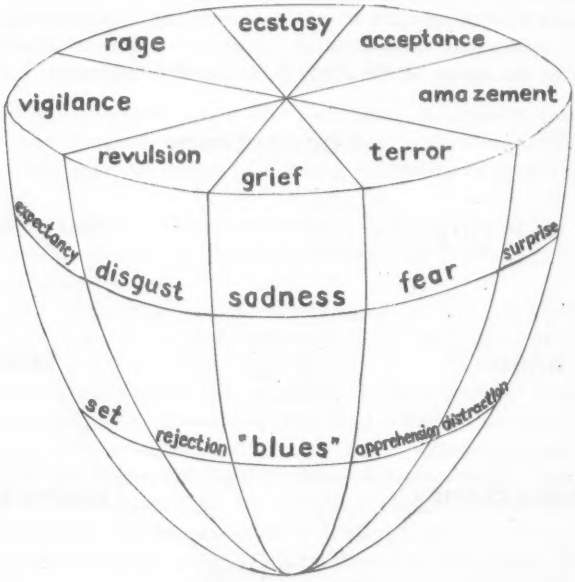


FIGURE 2. A multidimensional model of the emotions.

keep duplicating the emotion circle with progressively milder versions of each of the primaries. The relative differences between them also decrease as the intensity level of sleep is approached. The exact form which the emotion-solid shall take is an empirical question, and can be determined only by studies of level of arousal of the different primaries.

FIGURES 1 and 2 represent only the first step in the theory designed to show the nature of the primary units of analysis. Continuing the analogy with the color wheel, we can begin to synthesize more complex mixtures of emotions by combining the primaries in various ways. A mixture of any two primaries may be called a dyad, of any three primaries, a triad. However, these dyads and triads may be formed in different ways. From FIGURE 1 it is evident that it would be possible to combine any adjacent pair of primaries to form an intermediate emotion, just as any two adjacent colors form an intermediate hue. Such adjacent mixtures of emotions are called primary dyads. Mixtures of two primary emotions which are once removed on the circle are called secondary dyads, and mixtures of two primaries that are twice removed on the circle are called tertiary dyads. The same general method of designation would apply to triads, as well.

An important problem arises now as to how to name properly the mixtures that result. Because of the varying intensity levels there will be a certain element of arbitrariness. One criterion that is useful, however, is the requirement that opposite dyads tend to have opposing characteristics. This would be a criterion of internal consistency. Another approach might be to ask a group of judges to interpret the mixtures and to use the modal responses.

Both methods have been incorporated to produce the list of primary dyads shown in FIGURE 3. The names attributed to these various mixtures are, of course, tentative, and it is not always easy to name each combination of emotions. This may be due to one or more of several reasons: perhaps our language does not contain emotion words for certain combinations, although other languages might; perhaps certain combinations do not occur at all in human experience, just as chemical compounds can be formed only in certain limited ways; perhaps the intensity differences involved in the combinations mislead us in trying to decide on a suitable name; perhaps we must make up our own names to describe certain compounds; perhaps we have not yet discovered all the emotional combinations of which man is capable. In chemistry, when a gap was discovered in the periodic table it was still possible to discuss the properties of this hypothetical substance, to name it, and eventually to discover it.

However, certain internal consistencies do appear. This is illustrated in FIGURE 3 by the fact that pride is opposite shame, aggression is opposite alarm, and love is opposite misery. Another example of internal

FIGURE 3. A cross section of the emotion solid showing the primary dyads.

consistency is the fact that expectancy mixed with joy produces optimism but, when mixed with its opposite, sadness, produces pessimism. Similarly, acceptance and fear equal submission, while acceptance and anger equal dominance.

One possible way of dealing with the problem of naming emotion mixtures is to define them in terms of a "standard observer," as was done for colors by an International Commission on color naming.

TABLE 1 presents a tentative listing of all the dyads: primary, secondary, and tertiary. Several interesting points emerge from an examination of this table. First, almost all of the dyads listed represent emotions that are considered as relatively persistent. Emotions such as pride, aggression, submission, and optimism are usually long-lasting and, in fact, are often called personality traits. This implies that the formation of personality traits is related to the development of mixed emotions, a view that is consistent with many psychoanalytic concepts, as expressed, for example, by Fenichel.[10]

A second implication of the theory is that the movement from primary to tertiary dyads roughly parallels the differences between what might be called the normal emotions of everyday life and the clinical emotions. Thus, compare pride, love, curiosity, alarm, shame, misery, cynicism, and aggression with resentment, guilt, resignation, anxiety, envy, and fatalism. Dyads composed of every fourth emotion listed on the emotion circle would be mixtures of opposites and, as already noted, opposites neutralize, immobilize, or inhibit. In general, the more opposed two emotions are, the greater the conflict or inhibition produced by their mixture.

It should be evident that the theory can be extended to the mixtures of three emotions, although the problems of naming are proportionately greater. When we include triads, as well as dyads, and an intensity dimension as well, it becomes possible through the assumption of eight primary emotion dimensions to synthesize thousands of different combinations and thus potentially include all the emotions described in our language.

Although many other implications stem from the theory, limitations of space do not allow an extended analysis. Instead, only one issue will be discussed briefly: the question of repression and control of emotion.

From the point of view of the theory, one method for the control of emotions is through mixing them. We can control anger, for example, by mixing fear or expectancy either to dilute the anger (the term is used metaphorically) or partially to inhibit it. Think, for example, of the fact that in ordinary conversation we often say to a person, "Keep a stiff upper lip" or "Keep your chin up" in bidding him to hide or overcome sadness. Someone who has learned to hide all his emotions assumes a "dead pan" or "poker face." Do not these expressions indicate that we pit one bodily attitude against another in an effort to modify or reduce emotion?

TABLE 1

A TENTATIVE LIST OF THE PRIMARY, SECONDARY, AND TERTIARY DYADS

| *Primary Dyads* | *Secondary Dyads* | *Tertiary Dyads* |
|---|---|---|
| pride | dominance | resentment (outrage) |
| love | delight | guilt |
| curiosity | submission | resignation |
| alarm | disappointment | disgrace |
| shame | horror | anxiety (dread) |
| misery | scorn (contempt) | sullenness (envy) |
| cynicism | optimism | – – – |
| aggression | pessimism | fatalism |

The terms in parentheses are alternative designations of the emotion mixture. The dashed line indicates that no suitable name has been found.

In a paper written some years ago,[19] I presented considerable evidence to show that chronic tensions arise because adequate motor responses to conditions of conflict or frustration are impeded or blocked. These tensions reflect a continuous state of readiness of which an individual may often be unaware. From the viewpoint of this paper, these tensions would reflect the mixing of certain emotions, particularly those that are relatively far apart on the emotion circle. Certain implications relating to psychotherapy and mental health may also be drawn.

As outlined, the theory is still a tentative and evolving one[20] and will undoubtedly undergo some revisions as new research data become available. At the same time, many problems of research are indicated: for example, further studies of the behavioral, physiological, and subjective differences between the primary emotions, the nature of genetic changes in emotional expressiveness, the further analysis of tension patterns involved in the mixing of emotions, the development of an "emotional responsiveness" test as an index of adjustment, the development of standardized rules for naming emotion mixtures, the determination of the relation between personality typologies and the primary emotions, and differences between psychosomatic patient groups in terms of emotion tendencies.

Some research has already been started: one experiment[13] studied the relationship between patterns of facial expression and the primary emotions, with results that are reasonably consistent with the assumptions made here. One of my colleagues and I have developed a test of "emotional climate" for group interaction based on the primary emotions. The test has just been given to 600 college freshmen, and the connection between these scores and other measures of group interaction is now undergoing analysis. I am now working on a method for relating personality trait groupings to the emotion concepts presented here. I believe, in short, that the theory has many implications for research.

It is hoped that the theory will be judged in terms of its ability to relate a wide number of observations, including those on both positive and negative emotions; its ability to relate diverse areas of study such as personality formation and emotion; its ability to comment meaningfully on all of the issues with which an emotion theory must deal; and its fruitfulness in suggesting further research.

Since the theory assumes a number of factors or dimensions necessary for the analysis of emotional behavior, and since it utilizes the processes of analysis and synthesis, I suggest that it be called the multifactor-analytic theory of emotion.

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## *SECTION OF MATHEMATICS AND ENGINEERING*

# FLUID FLOW IN MULTIPARTICLE SYSTEMS*

*By* John Happel

*Department of Chemical Engineering, College of Engineering, New York University, New York, N. Y.*

Studies described in this paper are part of a long-range program [1-4] that has been conducted over a period of years and has the aim of achieving a better understanding of the principles underlying such phenomena as resistance to flow of fluids through beds, sedimentation of small particles, and viscosity of suspensions. Chemical engineers are interested in these problems because many contacting and catalytic reaction systems involve fixed and fluidized beds of particles. Seepage of underground water, flow of oil in wells, motion of dust and mist particles in the atmosphere, sedimentation of large organic molecules, and viscosity of plastics solutions represent a few examples of areas of interest in other fields of science and technology.

In order to construct tractable mathematical models of the complicated flow systems involved it is necessary to resort to a number of simplifications. In this treatment the inertia terms are omitted from the well-known Stokes-Navier equation of motion resulting in the so-called creeping motion equations. Many of the phenomena mentioned above occur in the Reynolds number range (based on particle diameter) of five or less and, as such, are amenable to mathematical treatment involving these hydrodynamic equations. Other simplifications include the assumption of uniform-sized particles, complete adherence without slippage on the particle surfaces, the approximation of a fluid continuum so that Brownian motion may be neglected, and the absence of extraneous forces, other than gravitation, such as electrostatic or surface tension effects. The justification for these assumptions rests in part on the conciseness of treatment thus made possible and in part on the good agreement of results with available experimental data.

Essentially, two techniques have been employed for handling boundary value problems involving a number of spheres, namely the method of reflections and the unit cell technique. In the method of reflections the equations of motion are satisfied successively on each of the separate bounding surfaces including the container walls of a suspension. If the system is sufficiently dilute, rapid convergence is possible.[3,4] The unit cell technique, on the other hand, involves the concept that an assemblage can be divided into a number of identical cells, one sphere usually

*This paper, illustrated with lantern slides, was presented at a meeting of the Section on February 21, 1958.

occupying each cell. The boundary value problem is thus reduced to a consideration of the behavior of a single sphere and its bounding envelope. This technique applies best if symmetry is more or less complete in the particle assemblage, and thus is of greatest applicability in concentrated assemblages where the effect of container walls can be neglected.

The unit cell technique is employed in the present paper. This general approach has been used by several investigators in the past for both sedimentation and viscosity studies. The treatment developed here is a new one that appears to give very good agreement with available experimental data. The mathematical derivation is developed on the basis that two concentric spheres can serve as the model for a random assemblage of spheres moving relative to a fluid. The inner sphere comprises one of the particles in the assemblage and the outer sphere consists of a fluid envelope with a "free surface." The appropriate boundary conditions resulting from these assumptions enable closed solutions to be obtained for the Stokes-Navier equations omitting inertia terms. These solutions enable rate of sedimentation or, alternatively, pressure drop to be predicted as a function of fractional void volume. In the case of shearing motion similar solutions relate relative viscosity of a suspension to solids concentration.

Perhaps the most striking confirmation of the theory developed is in the case of flow through packed beds. This has been the subject of a great number of experimental studies; perhaps the first were those conducted by Darcy on the filtration of water through beds of sand.[5] The law that Darcy discovered, namely that the rate of flow is proportional to pressure gradient through such a bed, is reported in his classic book. The correlation most widely used at present for resistance to flow through beds is the so-called Carman-Kozeny relationship.[6] This equation enables the effect of solids concentration to be estimated on a semitheoretical basis, but still requires the employment of an experimentally determined constant to characterize the solid medium involved. Thus,

$$V = \frac{(1-\phi)^3 a^2}{9 \phi^2 k \mu_o} \times \frac{\Delta p}{L} \qquad (1)$$

where $\phi$ is the fractional volume solids concentration, $a$ is the particle radius, $\mu_o$ is the fluid viscosity, $k$ is the experimentally determined Carman-Kozeny constant, $\Delta p$ is the pressure drop, $L$ is the length of bed, and $V$ is the superficial fluid velocity through a porous bed. The pressure gradient is $\Delta p/L$ and the multiplier of $\Delta p/(\mu_o L)$ is the Darcy constant.

For the case of uniform granular particles the Carman-Kozeny constant has been found experimentally to be equal to approximately 5. For absolutely uniform spheres the value of $k = 4.8$ is recommended, but the experimental accuracy of the data is probably no better than ± 10 to 15

per cent. The experimentally determined resistivity constant $k$ does not apply at solids concentrations less than $\phi$ = approximately 0.3. The present theory[7] in turn enables the experimentally determined constant to be eliminated, giving for its value

$$k = \frac{(1-\phi)^3 (3 + 2\,\phi^{5/3})}{6\,\phi - 9\phi^{4/3} + 9\,\phi^{8/3} - 6\,\phi^3} \tag{2}$$

In the range of solids concentration $\phi$ = 0.3 to 0.8 the theoretical relationship agrees on the average to within 8 per cent with the Carman-Kozeny equation employing $k$ = 5 and considerably better in the middle of the range. Since the resistance to flow in a bed corresponding to $\phi$ = 0.75 is approximately 400 times as great as if the particles were suspended in a very dilute medium, this can be considered very good agreement.

As solid particle concentration is reduced, the assemblage no longer takes the form of a fixed bed, but particles are free to move with respect to each other. The loose packed condition for uniform spheres corresponds to a solids concentration $\phi \simeq 0.53$. This is the point corresponding to incipient fluidization of solids beds and also is the concentration that corresponds to moving beds of uniform particles. With very small particles and those of irregular shape lower values of solids concentration may be reached before the fluidization occurs. In this range the rate of sedimentation of a particle in a suspension as compared with its rate of sedimentation in an unlimited medium (Stokes' law) is of interest. The following simple relationship shows the equivalence of this relative settling velocity and the resistance encountered to flow in fixed beds

$$\frac{U}{U_o} = \frac{1}{2k} \frac{(1 - \phi)^3}{\phi} \tag{3}$$

where $U$ is the velocity of sedimentation in an assemblage and $U_o$ is the sedimentation of a single particle in an unlimited medium. $U/U_o$ is termed the relative velocity. TABLE 1 gives a convenient tabulation of $U/U_o$ as a function of $\phi$.

Although the Carman-Kozeny equation fails in the intermediate concentration range corresponding to $\phi$ less than 0.3, the constant $k$ calculated from EQUATION 2 gives satisfactory results for the case where no particle agglomeration occurs, according to the rather scanty data now available. It appears, however, that agglomeration effects are substantial in most fluidized and sedimenting systems except in the very dilute range of solids concentration, $\phi$ less than 0.05. Values of relative velocity $U/U_o$ reported in the literature vary from 25 to 100 per cent higher than that predicted by the theory, with the exception of data recently obtained

under special conditions to avoid agglomeration effects. The "free surface" model thus gives a lower bound of relative velocity $U/U_o$ and perhaps corresponds to the condition representing uniform particle distribution, since any circulation or agglomeration effects will result in increased values for relative velocity. It is plausible to suppose that such agglomeration effects will be of greatest importance in the intermediate concentration region. In very dilute systems particles will not be sufficiently close to attract each other, whereas in concentrated systems mutual interference will result in a more or less uniform development of structure.

In the very dilute region the theory predicts marked effects of concentration on sedimentation rate. Thus, as $\phi$ approaches 0

$$\frac{U}{U_o} = 1 - 1.5\,\phi^{1/3} \tag{4}$$

At the dilute end of the solids concentration range, sedimentation data are available from a study by McNown and Lin[8] for a range of concentrations from 0.1 per cent by volume ($\phi = 0.001$) to 3 per cent volume concentration of solids. These data agree with the theoretical relationship developed here to within 2 to 15 per cent, best agreement being in the extremely dilute region. Several other theoretical relationships also show the same trend. However, a complicating factor in very dilute assemblages is the effect of the walls of the containing vessel on sedimentation velocity. This has been discussed by Happel and Brenner,[3] but further work is necessary to define the relative importance of particle to particle and particle to wall interactions. As in the case of systems of intermediate concentration it is likely that fraction solids concentration is not the only parameter characterizing relative velocity.

Further interesting studies, using the same "free surface" model, enable the behavior of systems consisting of cylindrical bodies to be evaluated. Correlations with flow parallel and perpendicular to assemblages of cylinders have been developed to enable the prediction of resistance. Here again, it appears that agreement with the Carman-Kozeny equation is good, at solids concentrations greater than $\phi = 0.3$. In this range the resistance is less in the case of parallel flow, but the weighted average of parallel and perpendicular orientations gives a Carman-Kozeny constant $k$ not far from 5. In the range of $\phi$ less than 0.3 the Carman-Kozeny equation again breaks down and the theory presented here should be more useful.

The same model may also be employed to estimate the viscosity of a suspension of particles.[9] In this case energy dissipation in a cell occupied by a spherical particle in a shearing field is compared with energy dissipation in the absence of the disturbance caused by the particle.

The relationship obtained is as follows:

$$\mu/\mu_o = 1 + 5.5\ \phi \left[ \frac{4\ \phi^{7/3} + 10 - (84/11)\ \phi^{2/3}}{10(1-\phi^{10/3}) - 25\ \phi\ (1-\phi^{4/3})} \right] \qquad (5)$$

where $\mu$ is the viscosity of the suspension and $\mu_o$ that of the pure fluid. $\mu/\mu_o$ is termed relative viscosity. TABLE 2 gives a convenient listing of values of $\mu/\mu_o$ as a function of $\phi$.

TABLE 1

EFFECT OF CONCENTRATION ON RELATIVE VELOCITY

| *Solids conc., Vol. fraction, $\phi$* | *Relative velocity $U/U_o$* |
|---|---|
| 0.001 | 0.8500 |
| 0.01 | 0.6773 |
| 0.05 | 0.4526 |
| 0.10 | 0.3215 |
| 0.20 | 0.1773 |
| 0.30 | 0.09867 |
| 0.40 | 0.05287 |
| 0.50 | 0.02638 |
| 0.60 | 0.01175 |
| 0.70 | 0.004340 |
| 0.80 | 0.001132 |

The theoretical relationship for viscosity shown in EQUATION 5 is in good agreement with data on suspensions of small spherical particles up to concentrations of 40 to 50 per cent by volume of solids. Above this concentration it is clear that friction due to interparticle contacts will become important and the resistance to shear will be much larger than predicted from purely hydrodynamic considerations.

In very dilute systems the theory developed does not agree with the well-known Einstein formula[10]

$$\mu/\mu_o = 1 + 2.5\ \phi \qquad (6)$$

The expression in brackets in EQUATION 5 reduces to 1 as the solids concentration approaches 0; thus EQUATION 5 would predict $k = 5.5$ instead of 2.5 as predicted by the Einstein relationship. It is believed that no single viscosity versus solids concentration function applies in extremely dilute systems, just as in the case of sedimentation, but that

TABLE 2

EFFECT OF CONCENTRATION ON VISCOSITY

| *Solids conc., Vol. fraction, $\phi$* | *Relative viscosity, $\mu/\mu_o$* |
|---|---|
| 0 | 1.000 |
| 0.05 | 1.281 |
| 0.10 | 1.605 |
| 0.15 | 1.997 |
| 0.20 | 2.486 |
| 0.25 | 3.115 |
| 0.30 | 3.942 |
| 0.35 | 5.062 |
| 0.40 | 6.621 |
| 0.45 | 8.861 |
| 0.50 | 12.200 |

varying results will be obtained depending on particle size and viscometer characteristics. However, at higher concentrations wall effects should become negligible.

In summary, the theory developed enables a concise formulation of the phenomena of sedimentation, resistance to flow, and viscosity over a wide range of solids concentration and without resort to any experimental constants. It may thus serve as a mathematical model for extension to more complicated cases, taking into account other variables such as inertial effects and variation in particle size and shape, as well as simultaneous effects of heat and mass transfer. The theory may also be useful in the development of empirical correlations of data obtained on particulate systems.

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THE NEW YORK ACADEMY OF SCIENCES

*SECTION OF GEOLOGY AND MINERALOGY*

# THE MACERAL CONCEPT AND THE STUDY OF MODERN ENVIRONMENTS AS A MEANS OF UNDERSTANDING THE NATURE OF COAL*

*By* William Spackman

*Department of Geology, Pennsylvania State University, University Park, Pa.*

## *Introduction*

Numerous attempts have been made to formulate an adequate definition of the word coal. Many of these attempts have resulted in lengthy discourses that devoted much attention to a consideration of source materials, to the coalification processes, and to discussions of the problems associated with differentiating coals from lignites and lignites from peats (Thiessen, 1947; Schopf, 1956). When brevity has been achieved, the definition has invariably lost the desired degree of informativeness. Although it may not be essential to incorporate into a definition information as to what coal has been and what it may become, it seems clear that, at a minimum, the definition should include a description of what the substance is in terms of the basic units comprising it.

To the chemist this might imply that coal should be defined as a complex mixture of carbon, hydrogen, oxygen, nitrogen, sulfur, and trace elements, or as a molecular aggregate of these materials. The elements, however, are the constituents of the aforementioned basic units and as such are not directly involved at what might be designated the critical organizational level. To make this point more apparent it is suggested that coal might be defined as a complex aggregation of protons, neutrons, and electrons. This certainly would be a true statement, but not a particularly useful one because it employs, in the definition, entities whose influence is imposed primarily at other than the critical organizational level.

The botanist formulating a definition of coal in terms of the basic units involved might suggest a characterization expressed in terms of certain cells, tissues, organs, and altered remnants of such structures. The organic fraction of coal is most certainly composed of altered plant material, but this again concerns something other than the critical organizational level unless attention is focused on the substances and aggregates of substances produced as the result of the various alteration processes. These substances and the optically homogeneous aggregates of substances are known as macerals.

*This paper, illustrated with lantern slides and motion pictures and presented at a meeting of the Section on February 3, 1958, is Contribution No. 57-74, College of Mineral Industries, Pennsylvania State University.

More specifically, macerals are organic substances, or optically homogeneous aggregates of organic substances, possessing distinctive physical and chemical properties, and occurring naturally in the sedimentary, metamorphic, and igneous materials of the earth. By virtue of its distinctive physical and chemical properties each maceral is the petrographic analogue of the mineral components in the earth's crust (Stopes, 1935).

From this it is now evident that coal may be concisely defined as a carbonaceous substance composed of phytogenetic macerals. Such a definition brings within the category of coal phyto-organic sediments of all "ranks" including peat, brown coal, lignite, subbituminous coal, bituminous coal, semibituminous coal, semianthracite, anthracite, metaanthracite and certain graphites. This seems quite proper and desirable, for these materials have long been recognized as members of a single system. This definition also includes, as coal, the myriad fragments of phyto-organic material found in shales, sandstones, and a variety of other lithologies. Evidence justifying inclusion of such materials within the concept of coal is to be found in many recent publications (Bates and Strahl, 1957; Berger and Schopf, 1955).

From the above it is evident that it is of paramount importance to all anthracologists, whether their interest is chemical, botanical, geological, or industrial, that progress should be made in establishing an adequate classification of macerals and that information should be amassed on the chemical and physical properties of these basic entities. Great strides in the latter direction are being made in Europe, as evidenced by the papers included in the published *Preprints of the Second International Conference on Coal Science* (Ladam, Iselin and Alpern, 1957; Kröger, 1957; Huntjens, Dormans, and van Krevelen, 1957) and by van Krevelen's and Schuyer's recent book entitled *Coal Science* (van Krevelen and Schuyer, 1957). In an effort to achieve greater stability in terminology and nomenclature, an International Commission on Coal Petrology is in the process of producing a glossary of terms through the work of a remarkably active, internationally constituted Glossary Committee. None of these efforts has been specifically directed toward achieving a systematic classification of macerals; in view of this, it is not surprising that little progress has been made in this direction. This is made even more understandable when it is recognized that an adequate classification can be conceived only after one has accumulated a reasonable amount of data concerning the things to be classified. The lack of complete data on maceral characteristics has inhibited effective classification of the various entities. Although this paucity of information on the chemical and physical properties of the macerals remains a problem, it appears advisable to suggest a skeletal framework upon which a systematic classification may ultimately be built.

### *The Nature and Classification of Macerals*

As implied in the foregoing discussion, small particles, large fragments, and great laminar beds or seams of organic matter are encountered in the earth's sediments. The more or less isolated particles or fragments may be composed of one or several macerals, and the coal seams are normally composed of many macerals and minerals, with the macerals predominating in both volume and weight.

A survey of the recorded characteristics of known macerals makes it evident that it is now possible to initiate a classification based on similarities of chemical and physical properties. This procedure appears particularly desirable because such properties are of considerable significance in connection with the industrial utilization of coal. A classification based on such parameters also meets the needs of organic chemists, geologists, and botanists for, as it is perfected, it becomes genetic as well as descriptive in character. This approach is quite different from that presented by van Krevelen and Schuyer who attempted to place macerals in categories on the basis of an inferred origin from "woody and cortical tissues" or "other than woody tissues" or "not yet traced to a specific vegetable tissue" (van Krevelen and Schuyer, 1957). The procedure proposed also differs appreciably from that of Thiessen, Parks, Schopf, and others, in which the "components" of coal are classified as anthraxylons, fusains, translucent attritus, or opaque attritus. These four categories comprise the major coal "constituents" (Thiessen, 1947; Parks and O'Donnell, 1956; Schopf, 1956a). Reference to these attempts to classify coal entities may appear nonpertinent to the discussion of maceral classification, for the coal components such as spores, cuticles, and translucent humic degradation matter are not macerals in the sense of the definition presented in the introduction to this manuscript. The chemical and physical properties of a spore change under the impact of the coalification processes, but the entity is still designated as a spore. In contrast, whenever the physical and chemical properties of a maceral are appreciably altered, of necessity it becomes another maceral and must be so designated. PLATE I shows, in a photomicrograph of a single thin section, two, or perhaps three, macerals that were derived from spore exines.

It must be admitted that thus far many investigators are employing the maceral concept in a manner that tends to equate components with macerals; hence, the concept as herein described deviates significantly from the commonly held ideas and represents a proposed – as opposed to an accepted – usage. Many coal petrologists would assert that the physical and chemical properties of a maceral are altered as the rank of the coal increases. Acceptance of the latter concept has confused coal science and coal scientists for decades. Although there exists an unquestionable relationship between maceral content and coal rank, it is of

the utmost importance to recognize that neither of these is capable of activating any process that could in any way influence the other. An approximation of the true relationship seems best expressed by suggesting that various physical and chemical agents and processes may effect alterations in the macerals comprising a coal, inducing the formation of new macerals; when the cumulative effect on the critical rank parameter has exceeded the prescribed threshold, the coal as a mass is designated by a new rank name. It follows that a maceral description will always be more definitive than a rank designation, for it will comprise a more specific and comprehensive statement of basic composition.

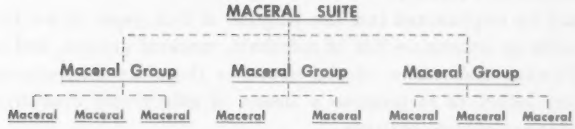
Use of the maceral concept as herein described facilitates the description and discussion of the processes of coalification and the formulation of precise statements of basic coal composition as implied above. In addition, the concept implements the classification of the products of coalification. Macerals possessing similar chemical and physical properties are readily assembled into Maceral Groups, which in turn can be characterized by a comparatively restricted set of properties. Maceral Groups possessing similar characteristics can be classified, if such proves desirable, into Maceral Suites. The proposed classification system is presented schematically in FIGURE 1a. In FIGURE 1b an attempt is made to demonstrate how the materials bearing some similarity to the vitrinitelike macerals might be classified. It should be understood that the number of macerals and maceral groups in any Maceral Suite will be dictated by the nature and variety of macerals that are encountered in the various carbonaceous sediments. It may be valuable to note that establishment of such Maceral Groups is unrelated to the grouping of macerals for purposes of expediency in working with triangular or quaternary diagrams (Stach, 1951; Mackowsky, 1954).

### *Common Macerals and Maceral Groups*

The vitrinoids and related groups form the bulk of most coal seams. The vitrinoids are particularly common in the Carboniferous coals of the Appalachian and mid-continent regions and, because certain of the vitrinoid macerals yield an effective binding residue upon carbonization, these areas produce quantities of good coking coal.

The xylinoids differ from the vitrinoids in many ways. For example, cellulose or holocellulose can be extracted from these xylinoid macerals, as was demonstrated in the studies of Barghoorn and Spackman on the Brandon, Vt., lignites (Barghoorn and Spackman, 1950). They contain sizable quantities of inherent moisture, causing them to slack quickly if placed in a dessicating environment; in thin section, they exhibit various shades of yellow-browns and red-browns that contrast with the several red hues, yellow-reds, and deep red-browns of the vitrinoid macerals.

Equally distinctive are the anthrinoid macerals that are completely opaque in normal thin sections; at the same time, when viewed in a hand




a. Generalized Scheme of Classification.

b. Possible Classification of Some of the Vitrinoids and Related Macerals.

FIGURE 1. Proposed scheme of maceral classification illustrating the manner in which it might be employed in relation to the vitrinoids and allied substances. *(a)* Generalized scheme of classification. *(b)* Possible classification of some of the vitrinoids and related macerals.

specimen, these possess the vitreous luster and uniform black tone that is so characteristic of the vitrinoids. Thus they appear to belong to the Vitrinite or Anthraxylous Suite, but comprise a group of macerals that are quite different from both the xylinoids and vitrinoids.

Other Maceral Groups unrelated to the Vitrinite Suite, but commonly encountered in the Appalachian coals, include the Micrinoid Group and the Fusinoid Group of opaque to semiopaque macerals (PLATE I). Because several of these macerals have been assembled for practical handling under the collective term of inertinite, it may be useful to consider these two groups as components of the Inertinite Suite. This is somewhat unfortunate, for the materials are by no means inert, but such a designation will aid in achieving the desired stability in nomenclatural practice.

At least two additional Maceral Suites are represented in Appalachian coals. The Resinous Suite contains a large and diverse assemblage of substances, some of which can properly be placed in the Abietoid Group (for example, succinite and certain other ambers) or in the Terpenoid Group (for example, monkey hair) or in the Resinoid Group that would include the golden yellow resinite and the red resine illustrated in PLATE I.

The Exinite Suite, for the moment, may be thought of as including the Exinoid Group and the Suberoid Group. Two examples of exinoid macerals are illustrated in PLATE I.

It should be emphasized that the purpose of this paper is not to define and describe an extensive list of macerals, maceral groups, and maceral suites. Further elaboration of the above is therefore inappropriate, for the primary intent is to propose a means of effectively classifying the various classes of coal entities.

*Natural Aggregates of Macerals and Minerals in Organic Sediments*

The macerals and minerals forming a coal seam are not randomly distributed through the thickness, breadth, and length of the bed. Instead, their occurrence is strongly conditioned, if not rigidly controlled, by the interaction of particular biological, chemical, and geological processes. These processes acting upon the given source materials yield distinctive assemblages of macerals and minerals. The various maceral assemblages are referred to as microlithotypes because, on a small scale, they represent discrete coal types. Microlithotypes may consist of one, two, or many different macerals, and it is usually the relative abundance of particular macerals that gives the particular microlithotype its unique character (PLATE II).

Maceral assemblages, under certain conditions, may be recognizable as remnants of specific plant cells, tissues, or organs. Such aggregates have been designated as phyterals (Cady, 1942), and the geologist and the botanist often find it useful to record phyteral distribution patterns in seams as aids in effecting correlations and in understanding environments. In addition to being formed of an assemblage of macerals, phyterals also may be formed of a single maceral. In some instances the actual botanical affinity of the phyteral can be ascertained, and this further implements research of this type. Seldom, if ever, is it possible to identify as particular phyterals all of the maceral material comprising a seam. In other words, a phyteral description of necessity leaves a portion of the seam undescribed. However, all of the organic material in the seam, including the material recognizable as phyterals, can be assigned to a microlithotype category.

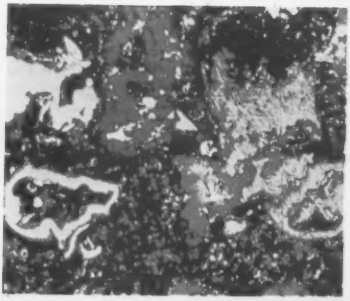
Thus, the maceral assemblages comprising coal seams may be thought of as consisting of two basic types: (1) those whose composition and structure is controlled by predepositional biological processes,* and (2) those whose composition and structure are controlled by post-depositional biological, chemical, and geological processes (these are not identifiable as phyterals, and may consist of one or more microlithotypes). PLATE II attempts to illustrate these two types of maceral assemblage.

*These are usually identifiable as particular phyterals; if large they may consist of several microlithotypes; if small they may represent simply a component of a particular microlithotype.

PLATE I. Variation encountered in optical properties within Maceral Groups. *(a)* Variation in resinoid material. Two resinoids are shown exhibiting the same elliptical form. The golden yellow material is resinite, the darker material is resine. (Lower Sunnyside seam; high volatile A coal; Geneva, Utah. × 25). *(b* and c*)* Bedding plane and vertical sections through different exinoids. The spore exines occur as bright yellow exinite, or as a brownish-red unnamed maceral. (B seam, high volatile A coal; Lynch, Ky. × 50). *(d)* Shows a central fusinite mass and *(e)* illustrates dispersed, granular, semi-opaque micrinoid material. (Mendenhall seam, lignitic coal; Harding County, S. Dak. × 70).

a

b



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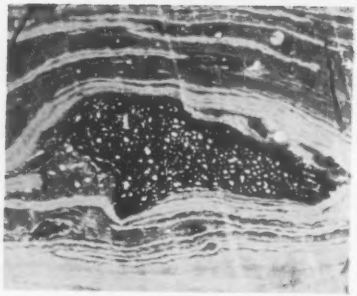

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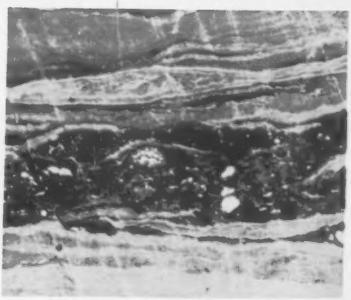

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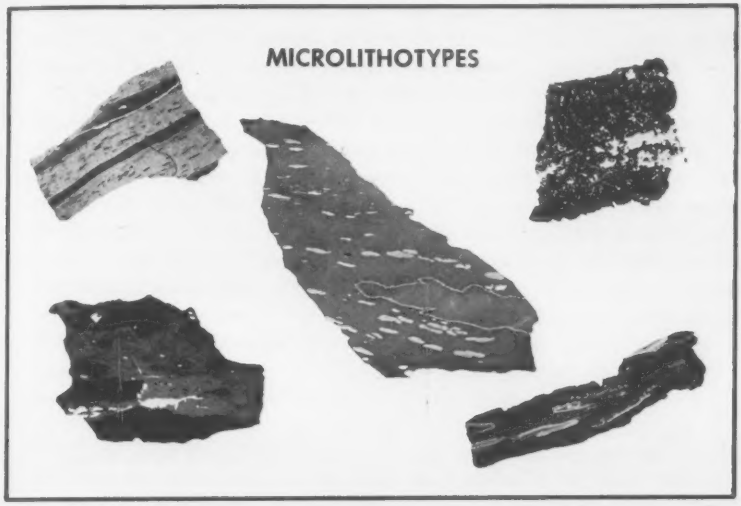
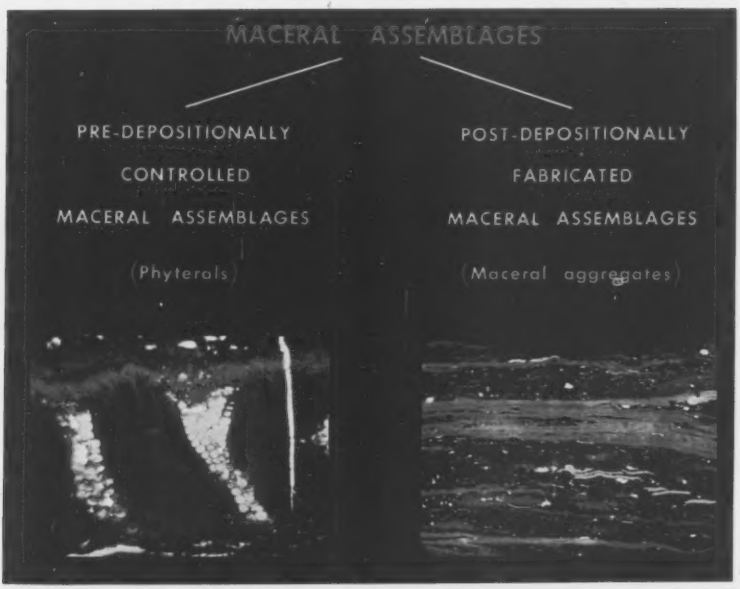

MICROLITHOTYPES

a


MACERAL ASSEMBLAGES
PRE-DEPOSITIONALLY CONTROLLED MACERAL ASSEMBLAGES
(Phyterals)
POST-DEPOSITIONALLY FABRICATED MACERAL ASSEMBLAGES
(Maceral aggregates)

b

PLATE II. Basic types of maceral assemblages. *(a)* Five examples of microlithotypes, all from lower Sunnyside seam, Geneva, Utah except durit particle in lower right which is from the B seam, Lynch, Ky. (×27). *(b)* A single phyteral composed of at least three macerals is shown in lower left illustration. It is a piece of bark derived from a Paleozoic lycopod. (Abdy seam, England. ×450). It should be emphasized that phyterals may also consist of a single maceral. A complex mixture of macerals is shown in the lower right illustration. The associations of the various fragments of material reflect little predepositional control. (High splint seam; Lynch, Ky. ×75).

Minerals participate in the formation of microlithotypes either as primary or secondary entrants into the mass. In addition, mineral aggregates may occur uncontaminated by macerals in the form of rock fragments and in various authigenic associations.

Of major interest is the fact that the macerals and minerals in a coal seam are assembled into readily recognized layers whose thickness is to be measured in inches, or even in feet, and whose areal extent may involve many square miles. FIGURE 2 shows the layers characterizing the B seam of Pottsville age in the vicinity of Lynch, Ky. As is implied by the graphic profile, coal seams usually are composed of many petrographic divisions or zones. These differ one from the other in both texture and composition. The diagram presented in FIGURE 2 reveals only the compositional differences on a mineral matter-free basis. Recognition of the petrographic zones comprising a seam normally requires a detailed microscopic examination of properly oriented thin or polished sections representative of every level in the seam.

Macroscopically, seams are divisible into layers that are spoken of as lithotypes. The lithotype profile of a coal seam is often a direct expression of the petrographic zones constituting the seam. In many instances, however, a single lithotype may be composed of two or more petrographic zones and, under such circumstances, it may be difficult to construct a lithotype profile from a knowledge of the petrographic zones and vice versa. As knowledge of the macroscopic characteristics of petrographic zones increases, this problem may be resolved.

Each of the petrographic zones and lithotypes evolves in a compositional sense as the coalification process proceeds. Although compositional dissimilarities appear to be reduced during the course of this evolution, a given lithotype can be differentiated from its neighboring units in an anthracite, using criteria similar to those employed in describing a high-volatile bituminous coal. This is of considerable significance to the geologist and botanist for, if the various zones and lithotypes can be related to particular ecologic and geologic conditions, a powerful tool is made available with which paleoecologies, paleogeographies, and geologic settings can be reconstructed. Equally important, insofar as the chemist and the petrographer are concerned, is the fact that, if the story of lithotype development is carried back to the peat stage and to extant environments, it becomes possible to reconstruct the geochemical history attending the evolution of macerals and maceral assemblages. Because it would then be possible to move gradually from the comparatively firm foundation of plant biochemistry into the problematical area of maceral chemistry, this is also a matter of great importance to those who seek to know more of how our coal resources might be used more effectively in producing metallurgical coke and chemical by-products.

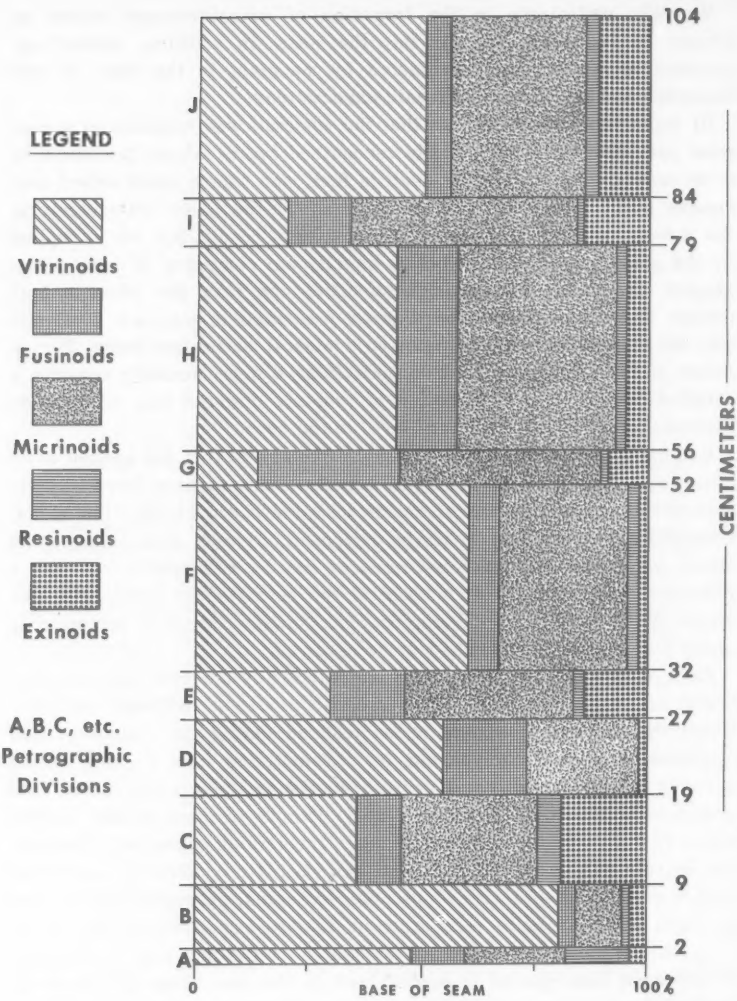



FIGURE 2. Microscopic petrography of the B seam, column No. 4, at Lynch, Ky., showing the composition of the several petrographic zones.

### *The Study of Modern Environments*

As the initial phase of an investigation of the biotic, geochemical, and geological factors related to the formation of lithotypes and the early evolution of macerals, field studies have been conducted in the coastal plain swamps of the southeastern United States. These have centered in

the Okefinokee Swamp of Georgia and in the Everglades and mangrove swamps of southern Florida. The range of variation in the environments in which peat accumulates in these areas is enormous. Some impression of this can be obtained by reference to FIGURES 3 and 4, which show four of the major environments encountered in tropical Florida. In each of these settings a characteristic type of peat is forming, and these various peat types represent the progenitors of the lithotypes that are encountered in lignites, bituminous coals, and anthracites. As time elapses, these environments may be altered as the result of the interaction of the aforementioned geological and biological processes with the result that a new peat type accumulates on top of that produced by the flora formerly occupying the site. Under the influence of a transgressing or regressing shore line, or as the result of simple plant succession, a series of peat types will become superimposed. Realizing this and recognizing the size of the areas covered by major coastal plain swamp environments, it is easy to understand why most coals are composed of several lithotypes, each having considerable lateral extent.

The discrete particles that compose the peats are commonly recognizable as fragments of tissues derived from particular plants that still live in the area. This permits a direct chemical comparison of the macerals composing the peat particle with the substances comprising the source tissues. Such comparisons should yield specific information on the structural chemistry of the peat macerals; this, in turn, should provide a basis upon which the chemistry of lignite and coals of higher rank can be more satisfactorily interpreted.

Examination of thin sections of compressed peat impresses one with the importance of the initial stages in the coalification process. In spite of the abundance of chlorophyll and other pigments, the bulk of the plant debris arrives on the surface of the peat as material that would appear essentially colorless in thin section. The botanist's reliance upon a multitude of stains to bring tissues, cell contents, and wall layers into contrast is ample evidence of this. Through chemical changes that have never been traced, these substances are converted into materials exhibiting a variety of yellows, browns, and reds. In some environments the sclerenchymatous endocarps of drupaceous fruits are converted to a yellow-brown maceral; in other environments they are rapidly destroyed, yielding, perhaps, soluble products that may or may not influence the coalification of adjacent materials. It is apparent that certain of the macerals formed at this stage are remarkably stable (for example, fusinite and certain resinoids), whereas others rapidly evolve into other entities. The cell walls of some tissues may become granular and semiopaque, approaching in character the material described from the Bolyston Street Fishweir site by Barghoorn (1949) and the coalified timbers taken from the Braunkohle mines in Germany, described by Varossieau (Varossieau, 1949). In other instances the cell walls appear to become

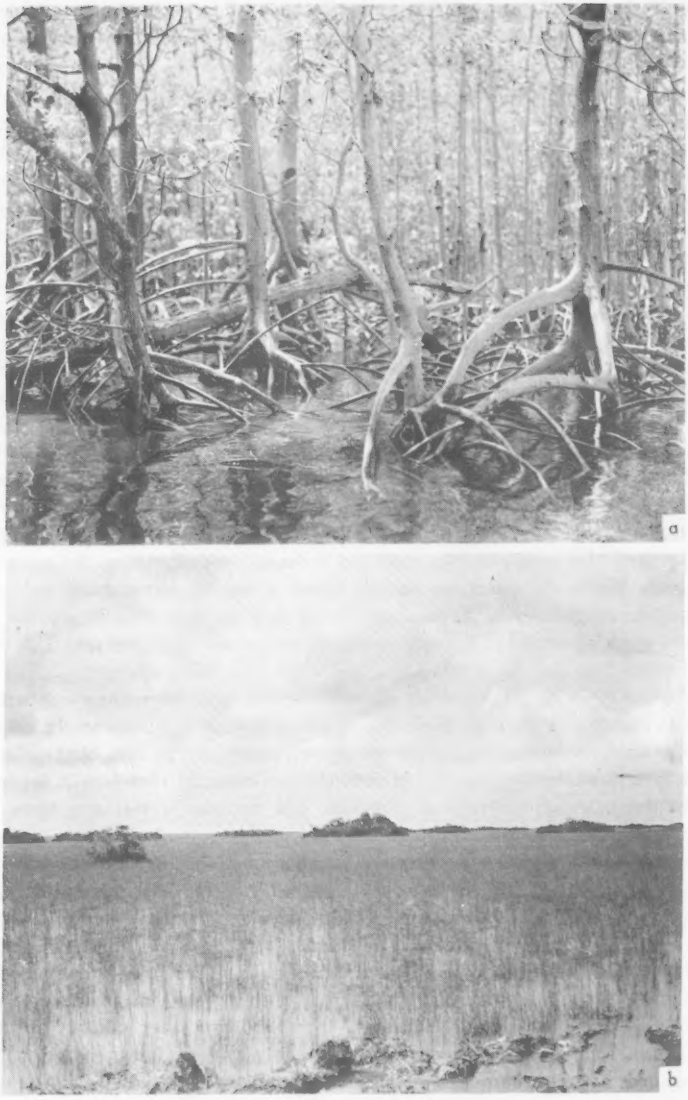


FIGURE 3. General aspect of two of the major swamp environments of tropical and subtropical Florida. *(a)* The fringe marine environment dominated by *Rhizophora mangle L.*, high salinity, and a delicate balance between peat and calcareous mud sedimentation. *(b)* The brackish Everglades environment dominated by sedges, and alkaline *p*H and an algal mat.

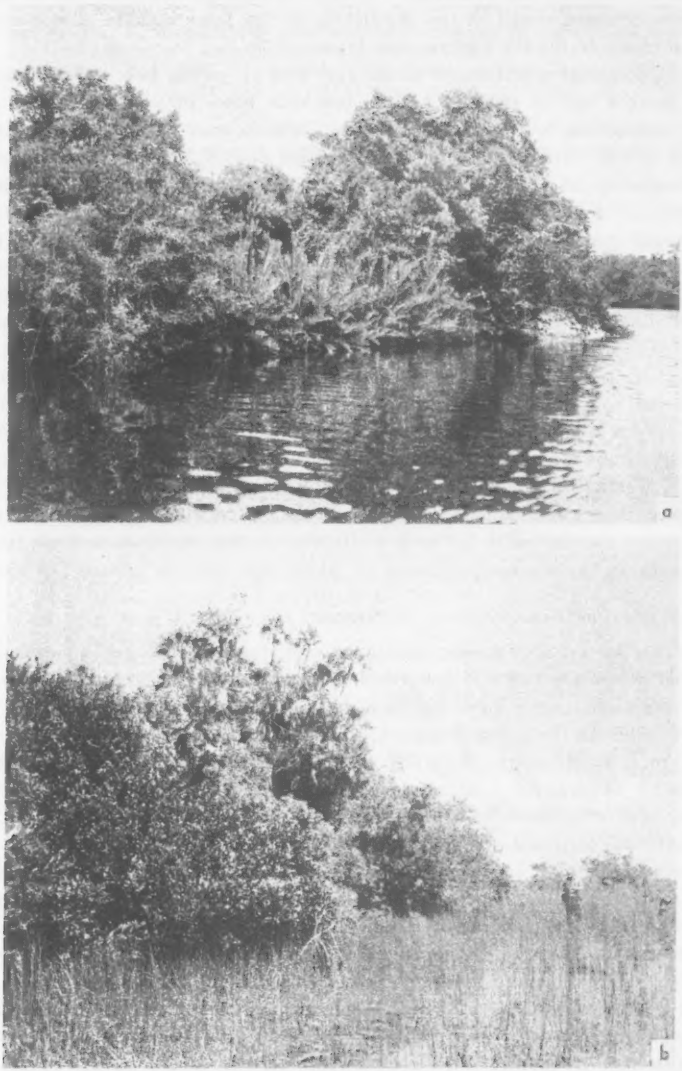



FIGURE 4. General aspect of two additional swamp environments of tropical and subtropical Florida. *(a)* A streamside swamp environment of mixed angiospermous vegetation approximately fifteen miles inland from the Gulf of Mexico. *(b)* A Paurotis palm—mixed hardwood hammock. The peat is in excess of six feet thick under the palm trees and it is less than one inch thick where the man is standing.

plastic without the occurrence of any evident granulation. These and other changes result in the production of the large number of macerals that characterize the various peat types.

Of potential significance is the fact that all of the peats encountered in marine and in strongly saline, brackish water environments were of an amorphous to finely fibrous type. This appears to hold true for the salt marsh environments of the temperate coasts, the sedge and grass everglades of the subtropics, and the forest mangrove swamps of the subtropical and tropical shores. The peat types associated with the various mangrove communities have been described in some detail by Davis and others (Davis, 1946), but never with a view to relating the accumulations to the lithotypes characterizing coals. It is of interest, therefore, to note that, in spite of the large quantity of periderm and secondary xylem that must inevitably be contributed to the accumulating mass (FIGURE 3a), these forest swamps will never yield the bright-banded, clarain lithotypes so frequently encountered in bituminous coals. It seems clear that this is not due to a lack of source material; it appears, instead, to be a direct result of the chemistry of the environment into which the lignified tissues fall. Thus, although the evolution of macerals is preconditioned by the nature of the starting materials, the changes that actually occur are effected by the chemical and physical agents in the microenvironment in which the particle passes its time.

*Summary*

Coal is a carbonaceous substance composed of phytogenic macerals. Coal seams are normally composed of several to many petrographic zones or divisions, each zone representing a distinctive mixture of macerals and minerals. It appears desirable to extend the concept of the maceral to include all petrographically discrete organic substances or assemblages of organic substances that possess distinctive chemical and physical properties and occur naturally enclosed in the strata of the earth. Depositional and coalification processes may form assemblages of macerals known as maceral aggregates. Macerals and maceral assemblages may reflect predepositional biological control; if they are identifiable as cells, tissues, or organs, they may be designated as phyterals. Dependent upon their size, maceral aggregates and phyterals may form components in microlithotypes or they themselves may be composed of several microlithotypes. Assemblages of microlithotypes form the petrographic zones and lithotypes of a coal seam. The latter are sedimentary units that frequently have considerable lateral extent as the result of their relationship to original swamp environments. Intensive study of swamp environments and their associated peat types yields information that is of vital importance in reconstructing paleoenvironments, in identifying coal seams, and in providing an understanding of the chemical composition of coal.

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## *SECTION OF ANTHROPOLOGY*

# RITUAL KINSHIP IN SPAIN*

*By* Julian Pitt-Rivers

*Visiting Professor, Department of Anthropology, University of Chicago, Chicago, Ill.*

The *compadrazgo*, a form of ritual coparenthood, has been studied extensively by anthropologists in the New World, but little attention has been paid to this same institution in its setting in the Hispanic Old World where, in spite of similarities of a morphologic nature, it does not appear to carry the same significance. The social ties that derive from it are two: (1) that between godparent and godchild; and (2) that between godparent and parent (*compadres*). In Central America the relation between *compadres* habitually outweighs in importance the relation between godparent and godchild, and its extensions have run to such exotic ceremonies as that which precedes the first nail-cutting of an infant or the breaching of a barrel of liquor. The significance of *compadres*, there, is primordially as a form of ritualized friendship and, as such, it has also been studied historically in Spain by Foster,[1] who is concerned with its importance "in stabilizing and integrating communal life" and, in Europe, by Mintz and Wolf[2] who "especially emphasize its function in furthering social solidarity." Whatever function the *compadrazgo* may fulfill in the wider society of the New World or may once have fulfilled in the Old World, its significance in the rural communities of Andalusia, where I studied it from 1949 to 1952, appears to be first and foremost as a form of kinship related to the structure of the family.

Ritual kinship derives from a concept that must be examined first, namely, spiritual affinity. This affinity is established by the fulfillment of specific roles in the ceremony of baptism (or confirmation) that are likened to relationships within the family in that they are compounded of the words for parent and child, as in English. I note that this analogy involves no kind of fiction, but rather a spiritual relationship that contrasts with the corporeal relationships of which the social family is composed. Like the corporeal family, however, ritual kinship imposes an incest prohibition.

I shall not describe the rite of baptism further than to point out that it is performed as soon as practicable after the birth of the child. It marks the acceptance of a soul into the Church, into the Christian community. As in English, *cristianar*, to christen, is an alternative way to say it. Baptism accords the remission of sins and, in particular, of Original Sin[3]

*This paper was presented at a meeting of the Section on February 24, 1958.

and, in consequence, should the infant die, it will go straight to Heaven and not to limbo or, as many theologians have thought, to Hell. The term *angelito* (little angel) is used to describe a deceased child, baptized but not yet arrived at the age of moral responsibility; for its death the bell is not tolled, but a quickly repeated note is rung upon the small bell (a *repique*) to announce its happy, if premature, union with the Almighty.

In baptism, the child receives its Christian name, which is the name of a saint under whose patronage it makes its entry into the community. This name is given to it by the godparent who receives it from the font and makes, on its behalf, the vows necessary for its acceptance.

The first observation to make is that the *padrino* (godparent) cannot be a parent; neither father nor mother can stand as sponsor to their child. There exists an explanation of the interdiction on a purely practical level. A woman must wait forty days after childbirth before going to church for the ceremony of purification and, since the child must be christened as soon as possible lest it die unbaptized, it follows that the ceremony, if it takes place in church, must take place without her. Regardless of the child's age, however, the mother never attends nor, in the greater part of Spain, does the father. The theological explanation of this disjunction of the two personalities of parent and godparent is based upon the juxtaposition of the ideas of natural paternity through which the sin of Adam was transmitted and spiritual paternity in the rite through which it is washed away; and the contrast is often made between corporal generation and spiritual regeneration.

Moreover, the prohibition of sponsorship by a parent is a logical corollary of the extensions of spiritual affinity during the early Middle Ages which were such that, were a parent to stand as sponsor, an incest prohibition would be established between husband and wife. The interdict was formally laid down at the Council of Mainz, in the Ninth Century. In fact, spiritual affinity was extended during the Middle Ages until an impediment to marriage existed even between the child of the *padrinos* and the brothers and sisters of the baptized. During the Renaissance, moreover, the fashion among the aristocracy demanded a large number of *padrinos*, with the result that the prohibitions of marriage resulting from godparentship became so complex that they tended to be disregarded. The Council of Trent (1545-1563) eventually put the matter right by limiting the number of *padrinos* to two and the extent of spiritual affinity to what it is in the popular imagination today: godparent-godchild, baptizer-baptized, godparent-parent.

The prohibition of sexual relations with either coparent or godchild is clearly understood by the people of Andalusia today and this is by no means due to their theological knowledge (the church has recently abolished the tie between parent and godparent), but to their conception of what the *compadre* and *padrino* are. For them the *padrino* is the person

who acts as a substitute for the parent in that relationship to the child from which the parent is excluded and in those rites that custom forbids the parent to attend. This definition holds equally good, at least in the plebeian tradition, for the *padrinos de boda*, the marriage godparents of whom nothing has been said so far, for neither do parents attend the wedding ceremony of their children.

There are, then, two distinct varieties of *padrino:* (1) marriage godparent *(padrino de boda)* and (2) godparent of the font *(padrino de pila).* Marriage godparents are the sponsors at the wedding. Their role is without spiritual significance and it is possible to be married without them from the religious point of view (on the other hand, a third variety, the godparents of confirmation are a liturgical necessity, but they have no social significance and will therefore be ignored). The marriage godparents' chief function is to pay for the religious ceremony, sometimes for the *arras,* the ritual gift of coins, and for part of the entertainment. The *padrinazgo de boda,* however, creates no *compadres.*

Both in the descent of surnames and in the transmission of property Spanish society is markedly bilateral. Property is divided equally among all children, so that inheritance derives from a man's four grandparents and will be distributed among his grandchildren.

The kinship terminology is similar to that in English, but terms exist to designate all the affinal kin in the first degree. The term for parent-in-law, *suegro,* is elaborated into a kinship term that has no equivalent in English: *consuegro. Consuegros* are said also to be *compadres,* for each is parent-in-law to the other's child, but the term *compadre* is more commonly used to designate the relationship between a natural and a spiritual parent, which is established by invitation and acceptance. *Consuegros* have chosen to be *consuegros* only to a limited extent; the children marry whom they will, but the *compadres* choose each other. Nevertheless, there are two rules that govern the choice of *padrinos:* (1) the *padrinos* are either a married or a betrothed couple; and (2) the marriage godparents should "baptize" (for they say "baptize" to indicate the act of becoming godparent) the first child of the marriage.

There is little agreement regarding the choice of the marriage godparents, but conservative people seem to follow one of two rules: one whereby the groom's elder brother and his wife are *padrinos de boda,* and subsequently the couple baptize the first-born. The reception on the first day is given by the bride's family in her house. That of the second day is given by the *padrinos.* In this way the expenses of the wedding are shared between the two families.

The alternative rule searches for balance in another quarter. There is a formal rule regarding the naming of children that is observed by all. The children are named after their grandparents in the following order: first son after paternal grandfather and first daughter after paternal grand-

mother; second son after maternal grandfather and second daughter after maternal grandmother. In this way the children are associated once more with their grandparents. In the choice of *padrinos* a further refinement occurs. By this rule the *padrinos de boda* are from the bride's family and, in consequence, the first child will get its Christian name from its paternal family and its *padrinos* from its maternal family. The *padrinos* of subsequent children are chosen with regard to the same principle: that its *padrinos* come from the opposite side to its Christian name. Within such a system, the ideal *padrinos* are the other pair of grandparents.

In those instances where there is no preferential rule to follow for the choice of the *padrino*, he is simply a close friend, seemingly a relative for preference or, less commonly, an influential person who is prepared to patronize the family. The essential thing is that he, or rather they, should be close friends *(de confianza)* of the parents. The importance of their feelings toward one another is particularly great in view of the relationship of *compadrazgo* in which they are henceforth to stand.

The relationship of *compadre* imposes certain forms of behavior upon the participants. In explaining what a *compadre* is, people say: "He is one of the family," meaning that he is received as if he were of the family, a mode of behavior facilitated in gallant Andalusia by the existence of the incest barrier, and they also explain: "You cannot refuse your *compadre* anything he asks. Anything that is yours is his." By implication anything that is his is yours, for the relationship is totally reciprocal. No difference in behavior, in obligations, or in form of address distinguishes the natural from the spiritual father in their mutual treatment. Each calls the other *compadre*. It is a relationship of absolute trust, and it involves the self-esteem of the participants in the highest degree. One can quarrel with one's family, but not with one's *compadre*. Therefore, while it frequently overlays a relationship of kin, it is not the same in kind as natural kinship. Fate determines who are one's kin, and one's obligations toward them are defined by custom and by law. However, one chooses one's *compadres*, and one's obligations toward them depend only upon their personal wishes.

Custom is explicit upon only one point. *Compadres* must address one another in the third person. This usage is the more remarkable within a community where people of the same age always speak in the second person. Therefore, two men who have spoken together all their lives in the familiar form adopt, from the day they become *compadres*, the formal *usted*. The reason given for this custom is always: "*Compadres* respect one another." This does not imply that their behavior becomes any more distant or unfriendly. Children speak to their parents in the third person for the same reason. Respect means maintaining a proper regard for an individual; it means the avoidance of the *laissez-aller*, which is the idiom between equals within the community; it means the recognition of dependence upon the good opinion of the other.

To summarize: the *padrinazgo* is a ritual relationship between a child and its substitute parents concerned with the personal destiny, religious and material, of the child, while the *compadrazgo* is an individual relationship in which the child provides the pretext for establishing a unique bond between two adult persons and their wives.

In the Andalusian countryside today, even though the institution remains constricted within the circle of family and close friends, one finds both forms stressed: that in which the *padrinazgo* is the important relationship, for example when a landowner takes on the duties of *padrino* to his tenant's child; and that in which the child's baptism is the occasion to inaugurate the *compadrazgo* between two old friends.

Turning to daily life to see how, within a living community, the institutions of kinship and ritual kinship interrelate, one must try first of all to evaluate the system of naming.

Everyone is addressed and known within the community by his Christian name and, if any title of respect is accorded on account of status or age, it is prefixed to the Christian name. The surname, on the other hand, defines a person to the outside world, defines him as a member of the nation, as the son of a certain household.

The Christian name is the first name by which its owner learns to recognize himself, for it is the name that distinguishes him within the family (he comes to learn his surnames only later when he goes to school). The Christian name is individual and not generic, and its whole significance can be derived from this fact. In matters of inheritance siblings have equal rights. They bear the same surnames and are usually known by the same generic nickname. Their Christian names distinguish them as individuals and unite them with other individuals of the same saint's name who celebrate their personal *fiesta* on the same day.

The word grace is sometimes used to refer to a person's first name and from this comes the expression for the godparents, *padres de gracia*. It is by Divine Grace that Original Sin is remitted through the rite of baptism. The association of this concept with the personal side of the social personality, as against the structural side represented by the surname, illustrates a contrast that is made in many ways in this society and is the basis of the juxtaposition of kinship and spiritual kinship.

It can be traced throughout the life cycle of the individual. The child goes to its baptism with members of its family, but without its parents. It is received from the font by the godparents, who pay for the ceremony and make the child certain specific presents. At the least, they must give it the cross or a religious medallion (usually of the Virgin). This medallion, which the child will wear always, is believed to be an effective protection against the Evil Eye. It is thought proper also to give an article of clothing for the occasion. A child's first pair of shoes should be given to him by his godparents, who again are responsible for

providing the elaborate dress for the girl's first communion, and the boy's first suit. Subsequently, the godparent is expected to do favors for the child, particularly in helping him to "get a start in life" and in general, to indulge his personal desires. The contrast between parent and godparent in relation to the child is evident. The parents are responsible for the child as a member of the family; they must teach it how to behave, they must punish it "to give it shame," and they must be respected by it in accordance with a number of established customs. For example, a son may not drink or smoke in the presence of his father. Parents and children are bound together by mutual responsibilities and reciprocal duties that last the whole length of their lives. The gifts of the godparent are free gifts, requiring no return.

Therefore, when the time of marriage comes at last and the couple set out with their wedding godparents for the church, they leave a world behind them. The romantic wooer becomes the head of a family. The days of courtship are over, and mutual concern regarding the state of the heart is replaced by common concern regarding the state of the household. The change is symbolized by the changed relationship with their *padrinos*. When the first child is born the *padrinos* become its *padrinos de pila*. To the parents they are now no longer *padrinos*, but *compadres*, persons between whom there are reciprocal responsibilities.

Another change is foreshadowed in the marriage. The parental couple are deserted by their children, one by one, who marry and move to another house, until the day comes when they remain alone. When they can no longer work their land nor go out for work they will become the dependents of their children. Then they are no longer parents, but grandparents, minor members of the household like their grandchildren, contributing the *durillo* (five pesetas) of their old-age pension as once they contributed their daily wage or the money they earned washing or carrying water.

When one considers the family in this society, it is evident that both the moral and also the economic basis for its extension are lacking. A family is never conceptually more than the two spouses, who have chosen each other for reasons of personal inclination, and their children. Consequently, the family may be said to be formed through the break-up of the parental family and to be destroyed through the formation of the filial family. This is one of the truisms of social anthropology. Given this, however, the *padrinazgo* appears as an institutional avoidance between parents and children whereby the conflict between the old family and the new is mitigated. The dispersion of the parental figures into natural parents and spiritual parents corresponds to the delegation, upon the occasions of the *rites de passage of* the children, of the role of parent.

The guardianship of the individuality of the child, his "Christian-self," that which will grow up and destroy the parental unit, is transferred to *padrinos* who have no concern in the structural destiny of the parental

family. The relationship between godson and *padrino* reminds one of that between nephew and mother's brother in certain patrilineal societies. The ideal person to fill this role of *padrino* is a member of the close kin of the parents who may be expected in any case to feel for the child the kind of indulgence proper to a godparent: a grandparent, or a father's or mother's brother or sister.

Consider now the horizontal dimension of the family: to begin with, the tensions are more obvious. Collateral kin are people who belong or will belong to different families. Shared participation in a common family is their tie. However, in every instance this participation establishes them in rivalry, not in cooperation. Between *consuegros*, relations are usually distant and jealous. The conventional rules that balance their claims in matters of Christian names and *compadrazgo* reflect their jealousy. The equality among siblings also inspires jealousy. A sibling is someone with whom one must share one's inheritance, and he is also someone who must share the duties and expenses of caring for aged parents. Siblings who are not on speaking terms with one another are no great rarity in Andalusia, and a person who does not speak with his brother- or sister-in-law is even less of an anomaly. Only mutual affection and shared affections keep them together.

Upon these ambiguous relationships the *compadrazgo*, with its obligation of absolute trust, is superimposed. Disregarding any conventional rule of selection, a *compadre* is first of all a person with whom there exists a mutual desire for such alliance. Thereafter the prescription that demands compliance with the wishes of the other guards against jealousy; that which ordains the third person guards against the familiarity that might breed contempt. This trust and this respect for the other's dignity are irrevocable. One cannot renounce *compadrazgo*. A man who quarrels with the spiritual parent of his own child desecrates his own personality. The self-esteem of each man is committed in this relationship in such a way that each is in the other's power. For this reason the *compadre*, as in Latin America, is the person *par excellence* from whom to borrow money. He cannot refuse to lend, nor can he refuse to repay. For the *compadrazgo* imposes the duty of cooperation in a way that kinship alone does not. It imposes a restraint in conduct, language, and feeling that is not to be derived from any other relationship. By delegating the spiritual parenthood of his child he binds himself to his chosen friend, who thereby champions the threat that the child's growing up represents to the integration of his family; between these two, however, there is simultaneously created a relationship within which no reproach is possible. The ties of spiritual affinity serve the purpose of exorcising from kin relationships the jealousies inherent in them. The elder brother who baptizes his nephew may thereby attach his indulgent concern to the child who will be his own son's *primo* (cousin), but he and his wife also

become *compadres* of his sister-in-law, the new arrival into the group of kin. Similarly, the grandparents who baptize at the same time become *compadres* of their son- or daughter-in-law. The *primo* who becomes *compadre* is no longer the potential "sucker" (the word *primo* has this figurative sense), but the sacred friend. Thanks to the *gracia*, which is the essence of spiritual kinship, the *compadrazgo* establishes a sacred bond between persons whose opposed interests threaten the solidarity of the family.

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## *DIVISION OF MYCOLOGY**

# INFLUENCE OF SOIL MOISTURE, pH, AND NUTRITION ON THE ALTERATION OF DISEASE PRONENESS IN PLANTS†

*By* Houston B. Couch and James R. Bloom

*Department of Botany and Plant Pathology, The Pennsylvania State University, University Park, Pa.*

The present-day concept of disease in plants allows for an intricately balanced relationship between host, pathogen, and their environments. This fundamental view of disease has not evolved in a simple, straight-line fashion; it represents, rather, a coming together of two strong and, in terms of time, unequally balanced schools of thought.

### *The Autogenetic Approach*

This concept pictured disease as exclusively physiogenic in nature. To the autogeneticist, plant maladies resulted from "internal disorganization of the nutrition process," and had "... their origin in a lack of certain chemical constituents of the sap" (Whetzel, 1918).

Under this philosophy, meditation, conditioned by preformed ideas, replaced objective, systematic inquiry. Consequently, it is not difficult to understand how almost 100 years after Tillet's classic demonstration of the infectious nature of *Tilletia caries* (DC.) Tul. (M. Tillet, 1750), a leading autogeneticist of the Nineteenth Century was able to assert without reservation that "... it is an established fact the cereal smut is not an infectious disease, but is one due to a stagnation of sap brought about by excessive and unnatural fertilizing." Reconciliation of the consistent occurrence of fungi with many diseases came with the theory that these microorganisms originated from diseased host tissue; that they were essentially transformed sap of diseased tissues, coming into being as the result of the exudation of morbid sap into intercellular spaces, where, under the influence of the live cells of the host, it was converted into the fungus structures (Whetzel, 1918).

Shattering of a concept of plant disease that had dominated scientific thinking for over eighteen centuries, therefore, relates to the establishment of the parasitic nature of fungi.

### *The Mycologic Approach*

The early part of the Nineteenth Century was characterized by a number of investigations that added weight to the suggestion that the "disease

*This paper, illustrated with lantern slides, was presented at a meeting of the Division of Mycology on February 28, 1958.

†Contribution No. 231 from the Department of Botany and Plant Pathology, the Pennsylvania Agricultural Experiment Station. Authorized for publication February 26, 1958.

organisms" of the autogeneticist actually caused the associated diseases, and were not the results but, in fact, the primary causes of the maladies. As the century progressed, the tempo of these investigations increased. Finally, with the publication of *Die Brand Pilze* (de Bary, 1853), the parasitic nature of the fungi associated with rust and smut diseases was proved conclusively, and the mycologic concept of plant disease was firmly established.

With the removal of the narrow views of the autogeneticist, knowledge of plant disease increased at a rapid rate for the next fifty years. The predominant concept of disease during this period was distinctly mycologic in nature. The terms mycology and plant pathology were used synonomously. As the result, concepts of the nature of disease were strong on fungus parasite, and decidely weak where host, environment, and the interrelationship among the three were concerned. So firmly entrenched was the fungus during this period that universal acceptance of bacteria as another group of plant pathogens came only after the classic investigation of Burrill (1881) and the subsequent research and dynamic salesmanship of Erwin F. Smith (Rodgers, 1952).

### *The Predisposition Approach*

The groundwork was now laid. However, development of the concept of disease that was so necessary to the emergence of plant pathology as a distinct discipline required the welding of the better physiological concepts of the autogeneticist and the views of the "mycologic" plant pathologist. This task was performed very effectively by the uncompromising predispositionist Paul Sorauer. The present-day concept of disease as, basically, an alteration in metabolism rests largely on his efforts (Sorauer, 1909).

In a recent treatment of the subject, Gaumann (1950) has pictured predisposition as a step in the process that activates the innate proneness of the plant to become diseased. This consideration, of a plant as possessing an innate ability to express a condition known as diseased, serves materially to emphasize the point that any environmental factor inducing an alteration in the constitution of the plant in turn may be reflected in its response to the presence of a given pathogen.

### *Soil Moisture and Disease Proneness*

Many plant species have been shown to respond sharply to varying soil-moisture stresses. For example, a reduction in soil-moisture content may bring about a reduced period of stomatal opening (Jones, 1931; Maximov and Zernova, 1936; Yocum, 1935). In addition, under conditions of high soil-moisture stress the photosynthetic processes may be retarded (Schneider and Childers, 1941).

Reduction in soil-moisture content may also be manifested in a material modification of the chemical composition of plants. Several workers have reported that moisture deficiency causes a decrease in starch content, and that it also causes a conversion of starch to sugar (Spoehr and Milner, 1939; Wadleigh and Ayers, 1945; Magness, Regembal, and Degman, 1933). Wheat plants grown under high soil-moisture stress have been reported to be higher in hemicellulose and sugars (Vassiliev and Vassiliev, 1936). The hemicellulose content of soybeans has also been reported to be higher under conditions of low soil moisture (Clements, 1937).

The manifold changes varying soil-moisture stresses induce in plant composition have yet to be extensively explored in the light of possible alteration in disease proneness.

In investigations concerned with growing plants, the basic problem to date has been centered on attempts to hold the soil system at fixed moisture levels in the range between field capacity (F. C.) and permanent wilting percentage (PwP)—an impossibility. Consequently, much of the work that has been done along this line must be interpreted in terms of variation of depth of wetting and, therefore, of variation in the total area of root activity, rather than in soil-moisture stress.

Actually, in an investigation of this type, reproduction of field conditions requires only a series of variations in the frequency of irrigation. This is accomplished by using tarred, nonporous containers filled by weight with uniform amounts of soil. The weight of each container at F. C. and PwP having been ascertained, the variable is introduced by allowing the plants to extract soil moisture to set points (by weight) between F. C. and PwP. When these points are reached, enough water is added to each container to bring the system back to the predetermined F. C. weight. The important feature of this technique is that the entire system must be irrigated back to F. C. each time. Any attempt to irrigate a system of this type back to any point below F. C. results only in a variation in the depth of wetting to F. C.

Using this approach, we have conducted a series of experiments testing the influence of the following soil-moisture levels on the susceptibility of seaside bent grass *(Agrostis palustris)* to *Rhizoctonia solani* Kuhn.: F. C., 3/4 F. C., 1/2 F. C., 1/4 F. C., and PwP. Inoculation was accomplished when the containers had reached the respective weight levels, and readings were made on the basis of actual count of plants killed. The results were subjected to analysis of variance.

Under the conditions tested, that is, soil-moisture stresses in the readily available range and exposure to *R. solani,* the disease proneness of seaside bent grass was not altered.

### *Nutrition, pH, and Disease Proneness*

In recent years the influence of nutrition on disease proneness has been investigated extensively. Schroeder and Walker (1942) found that resist-

ance of *Pisum sativum* to *Fusarium oxysporum* f. *pisi* (Lindf.) S. & H. increased with an increase in nutrient concentration when the plants were grown under long day conditions at 21° C. At 27° C. and long day lengths, disease severity increased with increased nutrient concentration. The susceptibility of cabbage to *F. oxysporum* f. *conglutinans* (Wr.) S. & H. has been found to increase with a decrease in potassium, and to decrease with decreasing levels of nitrogen and phosphorus (Walker and Hooker, 1945a). Susceptibility of this plant species to the clubroot organism (*Plasmodiophora brassicae* Wor.), however, increased with the omission of nitrogen and decreased with the omission of potassium and phosphorus (Walker and Hooker, 1945b). With the tomato, susceptibility to *F. oxysporum* f. *lycopersici* (Sacc.) S. & H. has been reported to increase under conditions of low potassium or high nitrogen. When grown at low nitrogen and high potassium, however, there was a decrease in disease development (Walker and Foster, 1946). Foley and Wernham (1957) found that a high nitrogen-potassium ratio (200:0) greatly increased the severity of stalk rot of corn, while a low nitrogen-potassium ratio (0:200) reduced the amount of internal rot and stalk breakage.

Soybeans have been found to be more susceptible to *R. solani* when grown under deficiencies of calcium, magnesium, iron, sulfur, nitrogen, and phosphorus. Examination of the cortical tissues of calcium-deficient soybean plants showed them to be poorly organized, with thin cell walls, poorly developed middle lamellae, and large intercellular spaces. This condition apparently allowed easy penetration on the part of the pathogen (Castano and Kernkamp, 1956).

In investigating the influence of nutrition and *p*H on the susceptibility of seaside bent grass to *R. solani*, we used a continuous-flow, drip-culture system, with silica sand as the supporting medium. The basal nutrient solution was identical to that designated by Walker and Hooker (1945a) as 1 H. Modifications of the basal solution (1 H) were made to contain one-tenth and three times the concentration of nitrogen, potassium, and phosphorus ions, respectively, in the basal solution. These solutions were all adjusted to a standard *p*H 5.6.

In another series, *p*H variables were introduced by adjusting hydrogen ion activity for the treatments 0.1 H, 0.1 N, 1 H, and 3 N at 5 levels ranging from *p*H 4.0 to *p*H 10.0. Readings for all series were taken as actual count of plants killed, and the results were subjected to analysis of variance.

A significant decrease in severity of the disease resulted when plants were grown at low nitrogen fertility. High nitrogen nutrition brought about a significant increase in disease incidence. High or low levels of phosphorus did not influence disease reaction; however, when the plants were grown under a low-level, balanced nutrition, a highly significant increase in disease severity was obtained. Under low nitrogen, alteration

of *p*H did not influence disease reaction. When grown at 1 H concentration, however, the plants were less susceptible to *R. solani* in the basic range.

## *Conclusions*

Although disease proneness is a heritable trait, comprehension of the extent of the disease proneness of a given plant comes only after its exposure to the different environmental conditions that may serve to modify its ability to express symptoms. Consequently, resistance and susceptibility are in many cases relative terms that serve only to measure the ability of the plant to become diseased under a very narrow range of conditions; as such, they may not be appropriate descriptions under another combination of predisposing factors.

While alteration of *p*H and nutrition may have a pronounced influence on disease proneness, the use of general plant vigor as a guide to susceptibility may be quite misleading. This point is borne out by our findings that low nitrogen fertility decreased the susceptibility of bent grass to *R. solani*, but a low balanced fertility increased disease proneness. On the other hand, high nitrogen increased susceptibility, while a high balanced solution, containing the same amount of nitrogen, offset this accentuated disease proneness.

The role of soil moisture in alteration of disease proneness has yet to be adequately explored and, as such, it represents an extremely fruitful area of endeavor.

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*CONFERENCES HELD*

*SECTION OF BIOLOGY*

# THIRD
# TISSUE HOMOTRANSPLANTATION CONFERENCE

*Thursday, February 6, and*
*Friday, February 7, 1958*

*Conference Co-Chairmen:*
John Marquis Converse and Blair O. Rogers

*Institute of Reconstructive Plastic Surgery, New York University-Bellevue Medical Center, and the Department of Surgery, New York University College of Medicine*
*New York, N. Y.*

## THURSDAY, FEBRUARY 6, 1958

## EMBRYONIC, FETAL, NEONATAL, AND INFANT TISSUE TRANSPLANTATION

*Session Chairman:* E. J. Eichwald
Montana Deaconess Hospital, Great Falls, Mont.

**9:00 A.M. –**
Greetings from the Academy – A. S. Gordon, Chairman, Section of Biology, The New York Academy of Sciences, New York, N. Y.; New York University, New York, N. Y.

Introductory Remarks – John Marquis Converse, Institute of Reconstructive Plastic Surgery, New York University-Bellevue Medical Center, and the Department of Surgery, New York University College of Medicine, New York, N. Y.

"Pulsatile Activity in Total Transplantation of Embryonic Mouse Hearts as an Index of Survival of Homotransplants" – Herbert Conway, B. Herold Griffith, John E. Shannon, and Angelica Findley, The New York Hospital, New York, N. Y.

"I. Homotransplantation of Embryonic Skin and Other Tissues on Conditioned or Normal Hosts" – Helene Wallace Toolan, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

"II. Clinical Application of Embryonic Skin Grafts" – Reuven K. Snyderman, Memorial Center for Cancer and Allied Diseases, New York, N. Y.

"Clinical Studies of Homografts of Fetal Skin" – Hamilton Baxter and Marcy Goldstein, Royal Victoria Hospital, Montreal, P. Q., Canada.

"Embryonic Parabiosis and Related Problems" – Milon Hasek, Czechoslovak Academy of Science, Prague, Czechoslovakia.

"Homotransplantation of Developing Toothbuds in the Rat" – H. H. Shapiro and D. Johnson, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"The Behavior of Skin Grafts Exchanged Between Parents and Offspring" – Lyndon A. Peer, The St. Barnabas Rehabilitation Center, Newark, N. J.

## IMMUNOGENETICS OF TISSUE TRANSPLANTATION

*Session Chairman:* H. Sherwood Lawrence

*New York University College of Medicine and the 3rd (N. Y. U.) Medical Division, Bellevue Hospital, New York, N. Y.*

**2:00 P.M. –**

"Comparative Immunology and Homotransplantation" – Cutting B. Favour, Palo Alto Medical Research Foundation, Palo Alto, Calif.

"Genetics of Transplantation in Xiphophorin Fishes" – Klaus D. Kallman and Myron Gordon, New York Zoological Society Genetics Laboratory, Genetics Laboratory, New York, N. Y.

"The Genetics of Tissue Specificity" – Allen S. Fox, Michigan State University, East Lansing, Mich.

"Induced Immunity to Cancer Cell Homograft in Man" – Chester M. Southam and Alice E. Moore, Sloan-Kettering Institute for Cancer Research, Research Unit of Memorial Center for Cancer and Allied Diseases, New York, N. Y.

"Reaction of Immune Lymphoid Cells and Homologous Tissue Antigens" – James H. Berrian, Naval Medical Research Institute, Bethesda, Md., and Leslie Brent, University College, London, England.

"Histocompatability in Inbred Strains of Guinea Pigs" – Joseph A. Bauer, Jr., National Institute of Allergy and Infectious Diseases, Public Health Service, Bethesda, Md.

"I. Full-Thickness Homografts of Skin in Golden Hamsters – Richard A. Adams, Children's Cancer Research Foundation, Boston, Mass.

"II. Studies on the Immunological Responses of Hamsters to Skin Homografts" – R. E. Billingham, The Wistar Institute, Philadelphia, Pa., and W. H. Hildemann, Kerckhoff Laboratories of Biology, California Institute of Technology, Pasadena, Calif.

## FRIDAY, FEBRUARY 7, 1958

## ANTIBODIES AND ANTIGENS IN TISSUE TRANSPLANTATION

*Session Chairman:* Merrill W. Chase

*The Rockefeller Institute for Medical Research, New York, N. Y.*

**9:00 A.M. –**

"Reactions Between Skin Homografts and Specific Immune Sera" – Chandler A. Stetson, Jr., and Rita Demopoulos, New York University College of Medicine, New York, N. Y.

"Host-Graft Interrelationship and the Effects Upon the Testes of Experimental Animals of Injections of Organ Homogenates or of Cells" – Seymour Katsh, Carnegie Institute of Washington, Baltimore, Md.

"Nature of Tissular Antigens with Particular Reference to Auto-Sensitization and Transplantation Immunity" – Guy A. Voisin, Francine Toulet, and Pierre Maurer, Hôpital Saint-Antoine, Paris, France.

"Attempts to Modify the Antibody Reactions in Kidney Homotransplantation by Protein Depletion and by Internal Irradiation of the Reticuloendothelial System" – P. F. Hahn, Meharry Medical College, Nashville, Tenn.

"Specific Desensitization of Guinea Pigs Sensitized to Protein Antigens" – J. W. Uhr, New York University College of Medicine, New York, N. Y.

"Antigens Involved in the Bone Marrow Transplantation Phenomenon" – T. Makinodan, Oak Ridge National Laboratory, Oak Ridge, Tenn.

"The Erythrocyte-Borne 'Antigen' in Tumor Immunity" – Morris K. Barrett, National Cancer Institute, Public Health Service, Bethesda, Md.

## GRAFT VERSUS HOST REACTION AND ACQUIRED TOLERANCE IN TISSUE TRANSPLANTATION

*Session Chairman:* R. E. Billingham

*The Wistar Institute, Philadelphia, Pa.*

**2:00 P.M. –**

"Studies on the Reaction of Injected Homologous Lymphoid Tissue Cells Against the Host" – R. E. Billingham, The Wistar Institute, Philadelphia, Pa.

"Tolerance and Homologous Disease in Irradiated Mice Protected with Homologous Bone Marrow" – John J. Trentin, Baylor University College of Medicine, Texas Medical Center, Houston, Texas.

"Tolerance to the Paralytogenic Activity of Nervous Tissue in Rats" – Philip Y. Paterson, National Institute of Allergy and Infectious Diseases, Public Health Service, Bethesda, Md., and New York University College of Medicine, New York, N. Y.

"A Study of X-irradiated Rabbits with Bone Marrow Homotransplants" – Kendrick A. Porter, St. Mary's Hospital, London, England; Fred Lee and Joseph E. Murray, Peter Bent Brigham Hospital and Harvard Medical School, Boston, Mass.

"A Study of the Graft Versus Host Reaction in Transplantation to Embryos, $F_1$ -Hybrids and Irradiated Animals" – Morten Simonsen, Fibiger Laboratory, Copenhagen, Denmark.

"Acquired Tolerance to Homografts and Heterografts in the Rat" – Richard H. Egdahl and R. L. Varco, The Medical School, University of Minnesota, Minneapolis, Minn.

"Unexpected Manifestations of Induced Tolerance to Skin Homografts in the Chicken" – Jack A. Cannon, Paul I. Terasaki, and William P. Longmire, Jr., University of California Medical Center, Los Angeles, Calif.

# *SECTION OF MATHEMATICS AND ENGINEERING, BIOLOGY, AND PSYCHOLOGY*

## CONTRIBUTIONS OF THE PHYSICAL, BIOLOGICAL, AND PSYCHOLOGICAL SCIENCES IN HUMAN DISABILITY

*Monday, February 10 and*
*Tuesday, February 11, 1958*

*Conference Co-Chairmen:*

Renato Contini, College of Engineering, New York University
New York, N. Y.

Sidney Fishman, Post-Graduate Medical School, New York University
New York, N. Y.

### MONDAY, FEBRUARY 10, 1958

#### AMPUTATION

*Session Chairman:* Sidney Fishman
Post-Graduate Medical School, New York University
New York, N. Y.

**9:00 A.M. –**
Greetings from the Academy – Lyle B. Borst, Chairman, Section of Mathematics and Engineering, The New York Academy of Sciences, New York, N. Y.; New York University, New York, N. Y.

"Prosthetic Replacement as Related to Extent of Physical Trauma" – Charles O. Bechtol, University of California at Los Angeles, Los Angeles, Calif.

"The Application of Engineering Technology to the Simulation of Human Motions" – Hans Mauch, Aeromedical Laboratories, U. S. Air Force, Air Force Research and Development Command, Dayton, Ohio.

"Phantom Phenomena and Sensory Functions Following Loss of Limb" – William B. Haber, New York, N. Y.

#### PANEL DISCUSSION

The Chairman, Speakers, and the following Discussants:

Samuel A. Weiss, Prosthetic Devices Study, College of Engineering, New York University, New York, N. Y.

Bertram D. Litt, Prosthetic Devices Study, College of Engineering, New York University, New York, N. Y.
Renato Contini, College of Engineering, New York University, New York, N. Y.

PANEL ON INTERDISCIPLINARY RESEARCH

*Session Chairman:* Frederick S. Strong
Prosthetics Research Board, National Academy of Sciences
Washington, D. C.

**2:00 P.M. –**
Each panelist will discuss the problems involved in the integration of the physical, biological, and psychological sciences, with regard to human disability. One of the following areas of emphasis will be covered by each speaker:

"The Purposes and Values of Interdisciplinary Research"
"Problems in Coordination and Supervision"
"Difficulties in Interdisciplinary Communications"
"Methods and Sources of Stimulating Interdisciplinary Research"
"Future Prospects"

PANELISTS:

I. Jay Brightman, New York State Interdepartmental Health Resources Board, Albany, N. Y.
Donald Dabelstein, Office of Vocational Rehabilitation, Washington, D. C.
Dale Lindsey, National Institutes of Health, Public Health Service, Bethesda, Md.
Harold K. Work, College of Engineering, New York University, New York, N. Y.

## TUESDAY, FEBRUARY 11, 1958

NEUROMUSCULAR DYSFUNCTION

*Session Chairman:* Herbert Elftman
College of Physicians and Surgeons, Columbia University
New York, N. Y.

**9:00 A.M. –**
"Analysis of the Hemiplegic Gait" – Morton Marks, Institute of Physical Medicine and Rehabilitation, New York University, New York, N. Y.

"The Psychological Adjustment Patterns of the Disabled" – Morton Seidenfeld, National Foundation for Infantile Paralysis, Inc., New York, N. Y.

"The Biomechanics of Pathological Gait" – Rudolfs Drillis, College of Engineering, New York University, New York, N. Y.

PANEL DISCUSSION

The Chairman, Speakers, and the following Discussants:

William Spencer, Southwest Polio Rehabilitation Center, Baylor University Medical School, Houston, Texas
Anthony Steras, Veterans Administration Prosthetics Center, New York, N. Y.

SENSORY DYSFUNCTION

*Session Chairman:* Franklin S. Cooper
Haskins Laboratories, New York, N. Y.

**2:00 P.M. –**
"Engineering Research on Problems Resulting From Sensory Loss" – Wallace E. Frank, Laboratories for Research and Development, The Franklin Institute, Philadelphia, Pa.

"Psychological Aspects of Sensory Disability" – Lee Meyerson, University of Houston, Houston, Texas.

"Research on Sensory Disorders" – Henry Imus, National Institute of Neurological Diseases and Blindness, Public Health Service, Bethesda, Md.

PANEL DISCUSSION

The Chairman, Speakers, and the following Discussants:

Nathaniel Raskin, The Children's Memorial Hospital, Chicago, Ill.
Howard Freiberger, Veterans Administration, New York, N. Y.
Joseph E. Hawkins, Post-Graduate Medical School, New York University, New York, N. Y.

ORGANIZING COMMITTEE

Renato Contini Sidney Fishman
Bertram D. Litt

## *SECTION OF BIOLOGY*

# THE UTERUS

*Wednesday, February 12,*
*Thursday, February 13,*
*Friday, February 14, and*
*Saturday, February 15, 1958*

*Conference Chairman:* Joseph T. Velardo
Yale University School of Medicine
New Haven, Conn.

*Conference Co-Chairmen*
William B. Ober, College of Physicians and Surgeons
Columbia University, New York, N. Y.
Herbert G. Winston, Albert Einstein College of Medicine
Yeshiva University, New York, N. Y.

## WEDNESDAY, FEBRUARY 12, 1958

### HISTORICAL AND MORPHOGENETIC CONSIDERATIONS

*Session Chairman:* Carl G. Hartman
Ortho Research Foundation, Raritan, N. J.

**9:00 A.M. –**
Greetings from the Academy – A. S. Gordon, Chairman, Section of Biology, The New York Academy of Sciences, New York, N. Y.; New York University, New York, N. Y.

Introduction to the Conference – Joseph T. Velardo, Yale University School of Medicine, New Haven, Conn.

"Historical and Cultural Aspects of the Uterus" – Alfred Plaut, Armed Forces Institute of Pathology, Washington, D. C.

"Embryology of the Uterus: Normal and Experimental" – Emil Witschi, State University of Iowa, Iowa City, Iowa.

"Growth and Development of the Uterus: The Relation of Epithelium to Mesenchyme" – Peter Gruenwald, Margaret Hague Maternity Hospital, Jersey City, N. J.

"Steroid Hormones and Uterine Growth" – Joseph T. Velardo, Yale University School of Medicine, New Haven, Conn.

*Discussant:* Thomas R. Forbes, Yale University School of Medicine, New Haven, Conn.

## BIOCHEMISTRY AND HISTOCHEMISTRY OF THE UTERUS

*Session Chairman:* Gordon W. Douglas
New York University College of Medicine
New York, N. Y.

**2:00 P.M. –**

"Biochemical Aspects of the Uterus" – James H. Leathem, Rutgers University, New Brunswick, N. J.

"Steroid Influences Upon the Lactic-Dehydrogenase-DPNH-Oxidase System of the Rat Uterus" – Arley T. Bever, Oklahoma University School of Medicine, Oklahoma City, Okla.

"Histochemical Observations of Oxidative Enzyme Systems in the Uterus of the Rat" – Charles G. Rosa, Jefferson Medical College, Philadelphia, Pa., and Joseph T. Velardo, Yale University School of Medicine, New Haven, Conn.

"Cytochemical Studies on Nonmalignant and Malignant Human Endometria" – Margaret E. Long and Fumio Doko, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"Estrogens and Uterine Enzymes" – Claude A. Villee, Boston Lying-in Hospital, Harvard Medical School, Boston, Mass.

*Discussant:* Lewis Engel, Massachusetts General Hospital, Harvard Medical School, Boston, Mass.

## PROBLEMS IN UTERINE TUMORS

*Session Chairman:* Alfred A. Angrist
Albert Einstein College of Medicine, Yeshiva University
New York, N. Y.

**8:30 P.M. –**

"The Development of Adenocarcinoma of the Uterine Fundus in Rabbits" – Harry S. N. Greene, Yale University School of Medicine, New Haven, Conn.

"Experimental Carcinoma of the Cervix" – William U. Gardner, Yale University School of Medicine, New Haven, Conn.

"Hydatidiform Mole and Choriocarcinoma" – Hugh G. Grady, Seton Hall College of Medicine and Dentistry, Jersey City, N. J.

"Uterine Sarcomas: Histogenesis and Taxonomy" – William B. Ober, Knickerbocker Hospital, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"Estrogens, Endometrial Hyperplasia, and Endometrial Carcinoma" – Ronald R. Greene, Northwestern University School of Medicine, Chicago, Ill.

*Discussant:* Sheldon C. Sommers, Massachusetts Memorial Hospitals, Boston University School of Medicine, Harvard Medical School, Boston, Mass.

## THURSDAY, FEBRUARY 13, 1958

### BLOOD COAGULATION IN PREGNANCY, LABOR, AND THE PUERPERIUM

*Session Chairman:* Howard C. Taylor, Jr.
College of Physicians and Surgeons, Columbia University
New York, N. Y.

**9:00 A.M.** –

"Mechanisms of Coagulation and the Hypercoagulable State: Intravascular Clotting and its Relation to the Fibrinogenopenic Accidents of Pregnancy and Delivery" – Mario Stefanini, St. Elizabeth's Hospital, and Tufts University School of Medicine, Boston, Mass.

"Coagulation Components in Normal and Abnormal Pregnancies" – Oscar D. Ratnoff, Western Reserve University School of Medicine, Cleveland, Ohio.

"Etiology of Fibrinopenia: Fibrination or Defibrination. The Fibrinogen-Fibrin Conversion Syndrome" – Charles Schneider, Dearborn, Mich.

"Etiology of Afibrinogenemia: Fibrinogenolytic and Fibrinolytic Phenomena" – Louise Phillips, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"Clinical Considerations in Afibrinogenemia" – Duncan E. Reid, Boston Lying-in Hospital, Harvard Medical School, Boston, Mass.

*Discussants:* Howard C. Taylor, Jr., College of Physicians and Surgeons, Columbia University, New York, N. Y.
Mario Stefanini, St. Elizabeth's Hospital, Tufts University School of Medicine, Boston, Mass.

### ASPECTS OF THE GRAVID UTERUS

*Session Chairman:* R. Gordon Douglas
New York Hospital, Cornell Medical School
New York, N. Y.

**2:00 P.M.** –

"Gestational Mechanisms" – S. R. M. Reynolds, University of Illinois College of Medicine, Chicago, Ill.

"Implantation" – Bent Böving, Carnegie Institution of Washington, Department of Embryology, Baltimore, Md.

"Vascular Adaptations of the Uterus to Pregnancy" – Elizabeth M. Ramsey, Carnegie Institution of Washington, Department of Embryology, Baltimore, Md.

"Dynamics of Amniotic Fluid" – Albert A. Plentl, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"Uterine Blood Flow" – Seymour L. Romney, Albert Einstein College of Medicine, Yeshiva University, New York, N. Y.

"Placental Clearance" – Gilbert J. Vosburgh, College of Physicians and Surgeons, Columbia University, New York, N. Y.

*Discussant:* Hugh G. Grady, Seton Hall College of Medicine and Dentistry, Jersey City, N. J.

## FRIDAY, FEBRUARY 14, 1958

### UTERINE CONTRACTIONS

*Session Chairman:* Seymour L. Romney
Albert Einstein College of Medicine, Yeshiva University
New York, N. Y.

**9:00 A.M. –**

"Innervation of the Uterus" – Kermit E. Krantz, University of Arkansas School of Medicine, Little Rock, Ark.

"Uterine Contractility, Blood Flow, and Urinary Steroids in Term and Premature Labor" – Paul D. Bruns, University of Colorado Medical Center, Denver, Colo.

"Chemistry of Uterine Contraction" – Arpad Csapo, Rockefeller Institute for Medical Research, New York, N. Y.

"Electrohysterography" – Charles Steer, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"Oxytocin and Contractility of the Pregnant Human Uterus" – Roberto Caldevro-Barcia, Montevideo, Uruguay.

*Discussants:* Louis M. Hellman, State University of New York Medical Center at New York, New York, N. Y.
S. R. M. Reynolds, University of Illinois College of Medicine, Chicago, Ill.

## MENSTRUATION AND MENSTRUAL DISORDERS

*Session Chairman:* C. Lee Buxton
Yale University School of Medicine
New Haven, Conn.

**2:00 P.M. –**

"Theories of Menstruation" – John Rock and Celso R. Garcia, Harvard Medical School, Boston, Mass., and Reproductive Study Center, Free Hospital for Women, Brookline, Mass.

"The Natural History of Menstrual Disorders" – Anna Southam, College of Physicians and Surgeons, Columbia University, New York, N. Y.

*Discussant:* Somers H. Sturgis, Harvard Medical School, and Peter Bent Brigham Hospital, Boston, Mass.

## STRUCTURAL AND FUNCTIONAL ASPECTS OF THE PLACENTA

*Session Chairman:* Roy O. Greep
Harvard School of Dental Medicine
Boston, Mass.

**3:15 P.M. –**

"Comparative Anatomy of the Placenta" – E. C. Amoroso, Royal Veterinary College and Hospital, London, England.

"Aspects of Placental Physiology" – A. St. G. Huggett, St. Mary's Hospital Medical School, London, England.

"Placental Hormones" – Joseph J. Jailer, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"Placental Transfer of Hormones in the Rat" – Ernest Knobil, Harvard Medical School, Boston, Mass.

"Chromosomal Sex Detection in the Fetus and Newborn from Examination of the Placenta and Umbilical Cord" – Arthur R. Sohval, Joseph A. Gaines, and Lotte Strauss, Mount Sinai Hospital, New York, N. Y.

*Discussant:* A. St. G. Huggett, St. Mary's Hospital Medical School, London, England

## SATURDAY, FEBRUARY 15, 1958

### AN EVALUATION OF NONSTEROIDAL OVARIAN HORMONES

*Session Chairman:* William U. Gardner
Yale University School of Medicine
New Haven, Conn.

**9:00 A.M.** –
"Historical Aspects of Relaxin" – Gustav J. Martin, National Drug Company, Philadelphia, Pa.

"Biochemistry of Nonsteroid Ovarian Hormones" – Edward H. Frieden, The Boston Dispensary, Boston, Mass.

"Effects of Estrogens, Progestagens, and Relaxin in Pregnant and Nonpregnant Laboratory Rodents" – Robert L. Kroc, Bernard G. Steinetz, and Vivian L. Beach, Warner-Chilcott Laboratories, Morris Plains, N. J.

"The Action of Relaxin on the Uterine Mucosa of the Rat, Mouse, and Rabbit" – M. X. Zarrow, Purdue University, Lafayette, Ind., and D. M. Brennan, University of Notre Dame, Notre Dame, Ind.

### PANEL DISCUSSION ON CLINICAL EFFECTS OF NONSTEROIDAL OVARIAN HORMONES

*Moderator:* Wayne H. Decker, Knickerbocker Hospital, New York University School of Medicine, New York, N. Y.

"Lutrexin in the Treatment of Premature Labor" – George H. Rezek, University of Illinois College of Medicine, Chicago, Ill.

"Effects of Relaxin on the Nonpregnant and Pregnant Uterus" – John V. Kelly, University of California Medical School at Los Angeles, Los Angeles, Calif.

"Effects of Relaxin on Dysmenorrhea" – Herbert S. Kupperman, New York University School of Medicine, New York, N. Y.

"Effects of Relaxin on Term and Premature Labor" – Martin L. Stone, New York Medical College, Flower and Fifth Avenue Hospitals, New York, N. Y.

"Effects of Relaxin on Term and Premature Labor" – Charles Birnberg, Brooklyn Jewish Hospital, Brooklyn, N. Y.

"Effects of Relaxin on Term and Premature Labor" – Eduard Eichner, Mount Sinai Hospital, Cleveland, Ohio.

*Discussant:* Daniel Abramson, Boston Lying-in Hospital, Harvard Medical School, Boston, Mass.

# ENZYMES IN BLOOD

*Wednesday, February 26* and
*Thursday, February 27, 1958*

*Conference Chairman:* Laurens P. White
*Stanford University School of Medicine*
*San Francisco, Calif.*

## WEDNESDAY, FEBRUARY 26, 1958

## ENZYMES IN WHITE BLOOD CELLS

*Session Chairman:* William S. Beck
*Massachusetts General Hospital, Boston, Mass.*

**9:00 A.M.**

Greetings from the Academy – A. S. Gordon, Chairman, Section of Biology, The New York Academy of Sciences, New York, N.Y.; New York University, New York, N. Y.

Introduction to the Conference – Laurens P. White, Stanford University School of Medicine, San Francisco, Calif.

"Leucocyte Glycolysis: An Investigation of the Factors Controlling Rate Behavior in Multi-Enzyme Systems" – William S. Beck, Massachusetts General Hospital, Boston, Mass.

"The Respiratory Enzymes in Leucocytes" – Richard Wagner, Boston Floating Hospital, Boston, Mass.

"On Myeloperoxidase" – Julius Schultz, Hahnemann Medical College and Hospital, Philadelphia, Pa.

"The Effects of Total Body Radiation on Leucocyte Alkaline Phosphatase Activity in the Rat" – William C. Moloney, Tufts University Medical School, Boston, Mass.

"Differences in Nucleic Acid Metabolism Between Normal and Leukemic Human Leucocytes" – Richard Winzler, University of Illinois, Chicago, Ill.

"Polynucleotide Synthesis in Leucocytes" – Leonard D. Hamilton, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

"Feed-Back Mechanisms Influencing Purine Nucleotide Biosynthesis" – James B. Wyngaarden, Duke University School of Medicine, Durham, N.C.

"Desoxyribonucleases and Desoxyribonuclease Inhibitor of Hematopoietic Tissue: Effect of Radiation" – N. B. Kurnick, Long Beach Veterans Hospital, Long Beach, Calif.

## ENZYMES IN RED BLOOD CELLS

*Session Chairman:* Efraim Racker
*Public Health Research Institute, New York, N. Y.*

**2:00 P.M. –**
"Recent Advances in Knowledge of the Hexose Monophosphate Shunt" – Frank Dickens, Middlesex Hospital Medical School, London, England.

"Studies on the Mechanism of Aging of Red Cells with Particular Reference to Alterations in Carbohydrate Metabolism" – Paul Marks, Francis Delafield Hospital, New York, N. Y.

"Hereditary Enzymatic Defect in Red Blood Cells: Its Relation to Certain Drug-Induced Hemolytic Anemias" – Ruth T. Gross, Stanford University School of Medicine, San Francisco, Calif.

"Organization of Red Cell Glycolytic Enzymes" – Grant Bartlett, Scripps Metabolic Clinic, La Jolla, Calif.

"Enzymes of Porphyrin Synthesis in Red Cells" – S. Granick, Rockefeller Institute for Medical Research, New York, N. Y.

"The Synthesis of Heme" – David Shemin, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"Regulatory Factors in the Interconversion of Glucose-5- and Ribose-5-Phosphate" – Zacharias Dische, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"Some Aspects of the Metabolism of Red Blood Cells from Patients with Hemolytic Anemias" – Kurt Altman, University of Rochester, Rochester, N. Y.

"The Metabolism of Purine Ribosides by Red Blood Cells" – Irving London, Albert Einstein Medical College, Yeshiva University, New York, N. Y.

"Problems Concerning the Activity of Carbonic Anhydrase in the Intact Red Cell" – F. J. W. Roughton and J. C. Rupp, Cambridge University, Cambridge, England.

"Methemoglobin Reductase in Erythrocytes" – Frank Huennekens, University of Washington, Seattle, Wash.

"The Permeability of Red Cells to Water and Ions" – A. K. Solomon, Harvard Medical School, Boston, Mass.

## ENZYMES IN BLOOD COAGULATION AND IN PLATELETS

*Session Chairman:* Walter Seegars
*Wayne State University, Detroit, Mich.*

**8:30 P.M. –**
"Is Thrombin the Only Enzyme Involved with Blood Coagulation?" – Walter Seegers, Wayne State University, Detroit, Mich.

"Thrombin and Its Interaction with Fibrinogen" – Harold Scheraga, Cornell University, Ithaca, New York.

"Phosphatides as Platelet Substitutes in Blood Coagulation" – Irving Schulman, Cornell University Medical School, New York, N. Y.

"Platelet Enzymes: A Survey" – Majorie Zucker, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

"Metabolism of Human Platelets as Affected by Storage, Hematological Disorders, and Thrombosis" – Edmund Campbell, The Lahey Foundation, Boston, Mass.

## THURSDAY, FEBRUARY 27, 1958

## SERUM ENZYMES AND THEIR ORIGIN

*Session Chairman:* Laurens P. White
*Stanford University School of Medicine, San Francisco, Calif.*

**9:00 A. M. –**
"Analytical Considerations in Serum Enzyme Determinations" – Ralph Thiers and Bert Vallee, Peter Bent Brigham Hospital, Boston, Mass.

"Muscle Membrane as a Dynamic Structure and its Permeability to Aldolase" – Kenneth Zierler, Johns Hopkins University, Baltimore, Md.

"Serum Enzymes in the Physiopathology of Muscle" – J. C. Dreyfus, G. Schapira, and F. Schapira, Hopital des Enfants Malades, Paris, France.

"Tissue Damage by Chemical Agents in Relation to Tissue and Serum Enzyme Levels" – F. S. Philips, O. Bodansky, J. Scholler, and S. Sternberg, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

"Clinical and Experimental Studies on Serum Pyridine-Nucleotide Linked Dehydrogenases in Liver Damage" – S. K. Wolfson, Jr., J. A. Spencer, R. L. Sterkel, and H. G. Williams-Ashman, Ben May Laboratory, University of Chicago, Chicago, Ill.

"Transaminase Activity in Suspensions of Parenchymatous Liver Cells" – Keith Henley, University of Michigan Medical School, Ann Arbor, Mich.

"Enzymological Studies on Congenital Galactosemia" – Herman Kalcker, National Institutes of Health, Public Health Service, Bethesda, Md.

"Hereditary Enzymatic Defects as Illustrated by Hypophosphatasemia" – Norman Kretchmer, Michael Stone, and Charles Bauer, Cornell University Medical School, New York, N. Y.

## SERUM ENZYMES AND THEIR ORIGIN

*Session Chairman:* William Fishman
*Tufts University Medical School, Boston, Mass.*

**2:00 P.M. –**

"The Heterogeneity of Malic and Lactic Dehydrogenases in Human Serum and Red Blood Cells" – Alick Bearn, Rockefeller Institute for Medical Research, New York, N. Y.

"On DPN-Dependent Enzymes in Serum" – Benno Hess, Medizinische Universitätsklinik, Heidelberg, Germany.

"Mode of Action of Heart Muscle Lactic Dehydrogenase" – George Schwert, Duke University School of Medicine, Durham, N. C.

"Mechanisms of Alterations of Lactic Dehydrogenase Activity in Body Fluids" – Felix Wroblewski, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

"Significance of Serum Aldolase Levels" – John Sibley, Iowa State University, Ames, Iowa.

"Enigmas in the Comparison of Multiple Serum Enzyme Levels" – Laurens P. White, Stanford University School of Medicine, San Francisco, Calif.

"Serum 5-Nucleotidase: Characterization and Evaluation in Disease States" – Irving Young, Wayne State University, Detroit, Mich.

"Serum Peptidases in Hepatic Disease" – G. A. Fleisher, Mayo Clinic, Rochester, Minn.

"Immunochemical Studies on Alkaline Phosphatase" – Max Schlamowitz, Roswell Park Memorial Institute, Buffalo, N. Y.

## PANEL DISCUSSION
## CLINICAL SIGNIFICANCE OF SERUM ENZYMES

*Session Chairman:* Oscar Bodansky
*Sloan-Kettering Institute for Cancer Research, New York, N. Y.*

**8:30 P.M. –**

William S. Beck, Massachusetts General Hospital, Boston, Mass.
William Fishman, Tufts University School of Medicine, Boston, Mass.
Alexander Gutman, Mt. Sinai Hospital, New York, N. Y.
Irving London, Albert Einstein College of Medicine, Yeshiva University, New York, N. Y.
Paul Marks, College of Physicians and Surgeons, Columbia University, New York, N. Y.
Lewis Thomas, New York University College of Medicine, New York, N. Y.
Laurens P. White, Stanford University School of Medicine, San Francisco, Calif.
Felix Wroblewski, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

ORGANIZING COMMITTEE

Laurens P. White, *Chairman*

Oscar Bodansky — William Fishman
Efraim Racker — Felix Wroblewski

# *NEW MEMBERS*

## *Elected February 27, 1958*

### *SUSTAINING MEMBERSHIP*

Bonner, William Albert, Ultraviolet Microscopy. Research Scientist, University of Texas Southwestern Medical School, Dallas, Texas.

Doyle, William T., Medicine. President, Nordmark Pharmaceutical Laboratories, Inc., Livingston, N. J.

Ellis, Paul Johnson, D.D.S., Periodontia. Dentist, Nashville, Tenn.

Farrell, John J., M.D., General Surgery. Professor, University of Miami School of Medicine, Miami, Fla.

Keevil, Norman B., Ph.D., Geophysics. President, Temagami Mining Company, Toronto, Canada.

Lang, Warren Reichert, M.D., Obstetrics. Assistant Professor, Jefferson Medical College, Philadelphia, Pa.

McCorkle, Henry Leonard, M.D., Physiology. Interne, U. S. Public Health Service Hospital, Baltimore, Md.

Nilson, Wesley G., M.M.E., Mathematics. Research Metallurgist, International Nickel Company, Inc., Bayonne, N. J.

Peterson, Thure C., Dr.Chir., Education. President, Chiropractic Institute of New York, New York, N. Y.

Roosa, Robert A., Ph.D., Cancer. Geneticist, National Cancer Institute, Bethesda, Md.

Rose, Virgil J., D.O., Surgery. Head, Department of Surgery, Orrville Community Osteopathic Hospital, Orrville, Ohio.

Smudski, Paul Allen, Ph.D., Chemistry. Research Chemist, The Carborundum Company, Niagara Falls, N. Y.

Tolkmith, Henry, Dr.Ing., Bio-organic Chemistry. Research Chemist, University of Berlin, Berlin, Germany.

### *ACTIVE MEMBERSHIP*

Abbott, Okra J., Ph.D., Biochemistry. Assistant Professor, Animal and Poultry Industry, University of Delaware, Newark, Del.

Abelson, Herbert I., Ph.D., Experimental and Social Psychology. Chief Psychologist, Opinion Research Corporation, Princeton, N. J.

Abowitz, Murray, M.D., Biology. Private Practice, Los Angeles, Calif.

Abrahamson, Edwin W., Ph.D., Photochemistry. Assistant Professor, Chemistry, State University College of Forestry, Syracuse, N. Y.

Adler, Jonathan Henry, Ph.D., Physiology. Head, Department of Physiology, Veterinary Institute, Beit Dagon, Israel.

Agersborg, H.P.K., Jr., Ph.D., Clinical Physiology. Instructor, University of Tennessee College of Medicine, Memphis, Tenn.

Alexander, Irving E., Ph.D., Psychology. Assistant Professor, Psychology, Princeton University, Princeton, N. J.

Allers, Rudolf, Ph.D., Psychology. Graduate Professor, Philosophy, Georgetown University, Washington, D. C.

Alonso, Darwin, Ph.D., Microbial Physiology. Assistant Professor, Microbiology, University of Puerto Rico School of Medicine, San Juan, Puerto Rico.

Alpert, Louis K., M.D., Cancer Chemotherapy. Clinical Professor, Medicine, George Washington University School of Medicine, Washington D. C.

Altshuler, Kenneth Z., M.D., Psychiatry. Senior Research Scientist, New York State Psychiatric Institute, New York, N. Y.

Andrews, Ralph C., M.D., Electro-encephalography. Chairman, Research Committee, Norwich State Hospital, Norwich, Conn.

Atkinson, John B., M.D., Hematology. Instructor, Medicine, Jefferson Medical College, Philadelphia, Pa.

Banovitz, Jay, Ph.D., Immunology. Research Associate, Institute for Cancer Research, Philadelphia, Pa.

Bare, John K., Ph.D., Physiological Psychology. Associate Professor, College of William and Mary, Williamsburg, Va.

Barlow, John S., M.D., Neurology. Assistant, Neurology, Massachusetts General Hospital, Boston, Mass.

Barr, Estelle DeYoung, Ph.D., Psychology. Psychologist, Westchester County Medical Health Board, Scarsdale, N. Y.

Barr, Murray L., M.D., Cytology. Professor, University of Western Ontario, London, Ont., Canada.

Barton, Theodore Claude, M.D., Biophysics. Research Fellow, Obstetrics, Boston Lying In Hospital, Boston, Mass.

Baruch, Jordan J., Sc.D., Engineering Research. Lecturer, Massachusetts Institute of Technology, Cambridge, Mass.

Bashey, Reza Ismail, M.S., Biochemistry. Research Fellow, Rutgers University, New Brunswick, N. J.

Baxter, Dow V., Ph.D., Forest Pathology. Professor, University of Michigan, Ann Arbor, Mich.

Baxter, Hamilton, M.D., Biology. Surgeon in Charge, Royal Victoria Hospital, Montreal, Canada.

Beloff, Ruth H., Ph.D., Pathology. Research Assistant, Yale University Medical School, New Haven, Conn.

Berdjis, Lt. Col. Charles C., Pathology. Chief, Fourth U. S. Army Medical Laboratory, Fort Sam Houston, Texas.

Bertinchamps, Albert Jacques, M.D., Nuclear Medicine. Research Associate, Brookhaven National Laboratory, Upton, L. I., N. Y.

Bianchi, John, B.S., Chemistry. Research Chemist, Johns-Manville Research Center, Manville, N. J.

Bickers, William, M.D., Obstetrics and Gynecology. Physician, Private Practice, Richmond, Va.

Biegeleisen, Joseph Z., Jr., Ph.D., Microbiology. Research Assistant, University of Oklahoma School of Medicine, Oklahoma City, Okla.

Bierwagen, Max E., Ph.D., Pharmacology. Senior Research Pharmacologist, Bristol Laboratories Inc., Syracuse, N. Y.

Biggers, Elizabeth Eugenia, Cytology. Tissue Culture Technician, New York, N. Y.

Black, Marion Eckert, M.D., Obstetrics. Assistant Clinical Professor, Western Reserve University Medical School, Cleveland, Ohio.

Boels, Willy M., M.D., Pathology. Chef de Travaux, Ghent University, Ghent Belgium.

Bondurant, Stuart, M.D., Physiology, Chief Medical Officer, Wright Air Development Center, Wright Paterson AFB, Ohio.

Bomside, George Harry, Ph.D., Microbiology. Assistant Research Professor, Louisiana State University, New Orleans, La.

Bower, Raymond Kenneth, Ph.D., Microbiology. Research Associate, University of Oklahoma, Oklahoma City, Okla.

Boyle, Albert J., Ph.D., Chemistry. Professor, Wayne State University, Detroit, Mich.

Brody, Jerome Ira, M.D., Internal Medicine. Resident, Internal Medicine, University of Pennsylvania, Philadelphia, Pa.

Brookens, Norris L., Ph.D., Clinical Medicine. Staff Member, Carle Hospital Clinic, Urbana, Ill.

Broussard, Mary Lou, M.S., Zoology. Instructor, Biology, Morris College, Sumter, S. C.

Brown, Richard J., M.D., General Surgery. General Surgeon, Private Practice, Owosso, Mich.

Burack, Bernard, M.D., Internal Medicine. Instructor, Clinical Medicine, Albert Einstein College of Medicine, New York, N. Y.

Burns, Loren V., M.S., Endocrinology. Director, Research, Kansas City, Mo.

Burt, Leland H., B.S., Chemistry. Hercules Powder Company, Wilmington, Del.

Butler, Byron Clinton, M.D., Biophysics. Gynecologist, Private Practice, Phoenix, Ariz.

Camp, Leon W., Ph.D., Physics. Engineering Consultant, Santa Monica, Calif.

Cannizzaro, Louis P., M.D., Medicine. Physician, Westbury, N. Y.

Carter, Mary Kathleen, Ph.D., Pharmacology. Instructor, Tulane University School of Medicine, New Orleans, La.

Casarett, Alison Provoost, Ph.D., Radiation Biology. Research Associate, University of Rochester Atomic Energy Project, Rochester, N. Y.

Cecil, Jack T., M.S., Protozoan Physiology. Bacteriologist, New York City Department of Health, New York, N. Y.

Chambers, Randall M., Ph.D., Physiological Psychology. Associate Professor, Rutgers University, New Brunswick, N. J.

Chany, Charles, M.D., Virology. Chief, Virus Section, St. Vincent de Paul Hospital, Paris, France.

Church, Brooks Davis, Ph.D., Bacterial Physiology. Senior Scientist, Warner-Lambert Pharmaceutical Company, Morris Plains, N. J.

Clement, David Hale, M.D., Medicine. Associate Clinical Professor, Pediatrics, Yale University School of Medicine, New Haven, Conn.

Colman, Henry Irving, M.D., Obstetrics. Attending Obstetrician, Queens General Hospital, Jamaica, N. Y.

Conley, Charles C., M.D., Pathology. Chief Resident, Pathology, Santa Clara County Hospital, San Jose, Calif.

Conrad, H. Edward, Ph.D., Biochemistry. Research Chemist, Mead Johnson & Company, Evansville, Ind.

Cooper, Franklin S., Ph.D., Psychoacoustics. President and Research Director, Haskins Laboratories, New York, N. Y.

Corson, Joseph Mackie, M.D., Tissue Homotransplantation. Associate in Pathology, Peter Bent Brigham Hospital, Boston, Mass.

Cosmides, George J., Ph.D., Neuropharmacology. Assistant Professor, Pharmacology, University of Rhode Island, Kingston, R. I.

Dancis, Joseph, M.D., Physiology of Placenta. Associate Professor, Pediatrics, New York University Medical Center, New York, N. Y.

Davis, James O., Ph.D., Physiology. Chief, Section of Experimental Cardiovascular Disease, National Heart Institute, Bethesda, Md.

Dees, Denzil E., D.V.M., Veterinary Physiology. Instructor, College of Veterinary Medicine, University of Illinois, Urbana, Ill.

Dennett, Roger H., M.D., Psychiatry. Psychiatrist, New Haven County Jail Project, New Haven, Conn.

Dennis, James L., M.D., Metabolic Disease in Childhood. Medical Director, The Children's Hospital of the East Bay, Oakland, Calif.

Deocampo-Buyco, Alicia, M.D., Pathology. Intern, St. Clare's Hospital, Schenectady, N. Y.

Devik, Finn, M.D., Radiobiology. Chief Medical Officer, Statens Radiologish-fysishe Laboratorium, Oslo, Norway.

Dickenson, James R., M.D., Director, Norwalk Hospital, Psychiatric Clinic, Norwalk, Conn.

Dimmick, Robert L., Ph.D., Bacteriology. Assistant Research Bacteriologist, Naval Supply Center, Oakland, Calif.

Dittbrenner, Mary, B.A., Biochemistry. Research Assistant, Yonkers, N. Y.

Donnell, George Nino, M.D., Pediatrics. Acting Medical Director, Children's Hospital, Los Angeles, Calif.

Dorfman, Howard David, M.D., Pathology. Resident, Surgical Pathology, Columbia-Presbyterian Medical Center, New York, N. Y.

Dougherty, Robert M., Ph.D., Virology. Instructor, Bacteriology, University of Rochester, Rochester, N. Y.

Drezner, Henry L., M.D., Cardiovascular Diseases. Chief, Cardiology, William Mckinley Memorial Hospital, Trenton, N. J.

Driscoll, Shirley G., M.D., Biochemistry. Research Fellow, Children's Memorial Hospital, Chicago, Ill.

Dumas, Jean, Dr.Eng., Aeomautics. Chief, Laboratory, Ecole Nationale Superiuere de l'Aeronautique, Paris, France.

DuVal, Merlin K., Jr., M.D., General Surgery. Associate Professor, University of Oklahoma Medical School, Oklahoma City, Okla.

Eberhart, Bruce M., Ph.D., Biochemical Genetics. Instructor, Princeton University, Princeton, N. J.

Ehrlich, Gabriele Loewy, Ph.D., Tissue Culture. Research Chemist, American Society of European Chemists and Pharmacists, New York, N. Y.

Elkort, Richard Jay, A.B., Biology. Student, New York University, New York, N. Y.

Enderlin, Martin, M,D,, Rheumatology. Head Physician, University of Zurich, Zurich, Switzerland.

Eng, Benny, M.S., Cytology. Research Assistant, Long Island City, N. Y.

Europa, Dominic L., B.S., Biology. Senior Histologist, Bellevue Hospital, New York, N. Y.

Faruki, Mahmud T., M.D., Neuropsychiatry. Chief, Receiving Service, Dayton State Receiving Hospital, Dayton, Ohio.

Feige, Norman G., B.S., Metallurgical Engineering. Senior Metallurgist, Combustion Engineering, Inc., Windsor, Conn.

Feigin, Emanuel V., M.D., Biology. Independent Research, Los Angeles, Calif.

Feorino, Paul M., M.S., Virology. Medical Bacteriologist, U. S. Public Health Service, Decatur, Ga.

Ferguson, Lloyd C., Ph.D., Microbiology. Professor, Michigan State University, East Lansing, Mich.

Fetterolf, Leo A., B.S., Biology. Research Pharmacologist, Smith, Kline and French Laboratories. Philadelphia, Pa.

Fink, Myron, M.D., Internal Medicine. Private Practice, Toledo, Ohio.

Fishel, Charles W., Ph.D., Immunology. Instructor, Department of Microbiology, University of Colorado Medical Center, Denver, Colo.

Forsyth, Robert L., M.D., Internal Medicine. Chief, Medical Division, West Pennsylvania Hospital, Pittsburgh, Pa.

Franca, Luiz C. Mattosinho, M.D., Pathology. Resident, Pathology, Baptist Memorial Hospital, Jacksonville, Fla.

Friedell, Gilbert H., M.D., Medicine. Instructor, Pathology, Boston University Medical School, Boston, Mass.

Friedman, Herman, Ph.D., Immunology. Postdoctoral Fellow, Microbiology Department, Hahnemann Medical College, Philadelphia, Pa.

Gangloff, Hanns, M.D., Neuropharmacology. Research Pharmacologist, University of California Medical School, Los Angeles, Calif.

Garfield, William M., B.S., Microbiology. Administrative Research Director, Laboratory for Therapeutic Research, Valley Stream, N. Y.

Gasque, Mac Roy, M.D., Industrial Medicine. Medical Director, Olin Mathieson Chemical Corporation, Pisgah Forest, N. C.

Gauthier, Robert J., Ph.D., Microbiology. Head, Biological Control, Smith, Kline & French Laboratories, Philadelphia, Pa.

Geus, Raymond J., B.A., Pharmacology. Pharmacologist, Smith, Kline & French Laboratories, Philadelphia, Pa.

Giedt, Walvin R., M.D., Epidemiology. Chief, Division of Epidemiology, Washington State Department of Health, Seattle, Wash.

Gilbert, Myron, M.D., Medicine. Senior Resident Physician, Bronx Municipal Hospital, Bronx, N. Y.

Giordano, Carmelo, M.D., Renal Diseases. Research Fellow, Cardiorenal Laboratory, Peter Bent Brigham Hospital, Boston, Mass.

Gohd, Robert S., Ph.D., Virology. Research Virologist, Massachusetts Eye and Ear Hospital, Boston, Mass.

Goldberg, Albert I., Ph.D., High Polymers. Associate Director, Research, National Starch Products, Plainfield, N. J.

Goldblatt, Julius E., M.D., Clinical Surgery. Private Practice, Lawrence, Mass.

Goldstein, Moise H., Jr., Sc.D., Communication Science. Assistant Professor, Massachusetts Institute of Technology, Cambridge, Mass.

Golomb, Frederick M., M.D., Cancer Chemotherapy. Instructor, Surgery, New York University Bellevue Medical Center, New York, N. Y.

Golub, Edward S., B.Sc., Microbiology. Graduate Student, Miami University, Oxford, Ohio.

Gordon, Herschel W., M.D., Pathology. Resident, Mt. Sinai Hospital of Miami Beach, Miami Beach, Fla.

Gorrie, Rachael H., M.S., Virus. Bacteriologist, U. S. Public Health Service, Chamblee, Ga.

Gottfried, Eugene L., M.D., Medicine. Assistant Resident, Medicine, The Presbyterian Hospital, New York, N. Y.

Goulet, Normand R., Ph.D., Biology. Director, Vaccine Production, National Drug Company, Swiftwater, Pa.

Granoff, Morris Aaron, M.D., Medicine. Physician, Private Practice, New Haven, Conn.

Greenberg, Joseph, M.D., Nuclear Medicine. Chief, Division of Nuclear Medicine, The Long Island Jewish Hospital, New Hyde Park, N. Y.

Grossman, David L., B.A., Medical Research. Research Assistant, Newark Beth Israel Hospital, Newark, N. J.

Grote, Irvine W., Ph.D., Organic Chemistry. Head, Department of Chemistry, University of Chattanooga, Chattanooga, Tenn.

Gundel, Robert E., M.D., Medicine. Assistant Medical Director, The Purdue Frederick Company, New York, N. Y.

Gutierrez-Vazquez, J.M., Bacteriology. Chemist, Assistant Director, Nacional de Ciencias Biológicas, Mexico, D. F., Mexico.

Halberg, G. Peter, M.D., Ophthalmic Electrophysiology. Assistant Director, Division of Electrophysiology, New York Eye and Ear Infirmary, New York, N. Y.

Halle, Morris, Ph.D., Linguistics. Associate Professor, Department of Modern Languages, Massachusetts Institute of Technology, Cambridge, Mass.

Hallenbeck, Rev. Luke J., M.S., Physiologic Hematology. High School Biology Teacher, The Abby School, Canon City, Colo.

Harmon, Leon D., B.S., Automata. Member of Technical Staff, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

Harris, William Henry, B.S., Mental Health. Biochemist, Connecticut State Hospital, Middletown, Conn.

Hartmann, George C., M.A., Mycology. Teaching Assistant, Department of Biological Sciences, Purdue University, Lafayette, Ind.

Haven, Frances L., Ph.D., Biochemistry. Associate Biochemistry, University of Rochester School of Medicine, Rochester, N. Y.

Henderson, Muriel, Physiology-Metabolism. Attending New York University Medical Center, New York, N. Y.

Henlein, Lore, B.A., Natural Sciences. Advertising Manager, Academic Press Inc., New York, N. Y.

Herman, Rose, M.D., Psychiatry. Psychiatrist, Private Practice, Cleveland, Ohio.

Hertzberg, Joseph M., M.D., Obstetrics. Toledo Hospital, Toledo, Ohio.

Hickman, Robert O., M.D., Pediatrics. Intern, Pediatrics. Layton, Utah.

Hilton, James G., Ph.D., Autonomic Cardiovascular Pharmacology. Associate Professor, Pharmacology, University of Mississippi Medical Center, Jackson, Miss.

Ho, Monto, M.D., Medicine. Research Fellow, Children's Medical Center, Boston, Mass.

Hochstein, Paul, Ph.D., Hormone Action Associate, Department of Biochemistry, Columbia University, New York, N. Y.

Hoffman, Howard E., Ph.D., Chemistry. Research Chemist, E.I. du Pont de Nemours, Newark, Del.

Holbert, James M., Ph.D., Pharmaceutical Chemistry. Vice-President for Research, The Chattanooga Medicine Company, Chattanooga, Tenn.

Hollander, David H., M.D., Pathology. Senior Physician, Montebello State Hospital, Baltimore, Md.

Hoshino, Kazumasa, M.D., Obstetrics. Resident of Obstetrics and Gynecology, St. Clare's Hospital, Schenectady, N. Y.

Hoyt, H. Spencer, M.D., Kidney Disease. Physician and Surgeon, Monterey, Calif.

Hubbard, Ethel-May, M.T., Cancer Chemotherapy. Research Assistant, Wyeth Laboratories, Philadelphia, Pa.

Hughes, Edwin R., M,D,, Medicine. Trainee in Arthritis and Rheumatism, University of Utah, Salt Lake City, Utah.

Hupf, Homer B., B.Sc., Pharmaceutical Education. Graduate Student, Philadelphia College of Pharmacy and Science, Philadelphia, Pa.

Hurst, Valerie, Ph.D., Microbiology. Assistant Professor, University of California Medical Center, San Francisco, Calif.

Iovino, Anthony Joseph, M.S., Endocrinology. Assistant Professor, Long Island University, Long Island, N. Y.

James, Eleanor, Biology. Biologist, American Cyanamid Company, Pearl River, N. Y.

Johnson, Harold L., M.D., Anesthesiology. Department of Anesthesiology, Kings County Hospital, Brooklyn, N. Y.

Jones, Alfred Welwood, Ph.D., Mathematics. Member, Technical Staff, Bell Telephone Laboratories, New York, N. Y.

Jonsson, Ulfar, M.D., Hematology. Assistant Professor, Medicine, University of Miami School of Medicine, Miami, Fla.

Kahn, David, M.D., Pathology. Director, Laboratories, Laboratory of St. Mary's Hospital, Montreal, Canada.

Keesing, Abraham, M.D., Medicine. General Practitioner, New York, N.Y.

Kemeny, John L., M.D., Psychiatry. Psychiatrist, Private Practice, Schenectady, N. Y.

Kereiakes, James G., Ph.D., Biophysics, Physicist, U. S. Army Medical Research Laboratory, Fort Knox, Ky.

Kesten, Jacob, M.S., Psychology. Psychiatric Caseworker, Private Practice, New York, N. Y.

Kester, Wayne Otho, D.V.M., Veterinary Medicine. Executive Vice-President, Microbiologicals Associates, Inc., Washington, D. C.

Keusch, Kenneth David, A.B., Biology. Graduate Student, New York University, New York, N. Y.

Kimura, Ren, Tissue Culture. Dean, Nagoya University, Kyoto, Japan.

Kleefeld, Georges, M.D., Ophthalmology. Ophthalmologist, New York, N. Y.

Klein, Richard M., Ph.D., Psychology. Instructor, Oregon State College, Corvallis, Oreg.

Knapp, Barton W., M.A., Clinical Psychology. Chief, Clinical Psychology Section, New Jersey Neuropsychiatric Institute, Princeton, N. J.

Kobayashi, Yutaka, Ph.D., Biochemistry. Scientist, Worcester Foundation for Experimental Biology, Chicago, Ill.

Kooperstein, Samuel L., M.D., Biology. Medical Director, Port of New York Authority, New York, N. Y.

Korst, Donald R., M.D., Internal Medicine. Chief, Radioisotope Service, University of Michigan Medical School, Ann Arbor, Mich.

Kraybill, Henry L., Ph.D., High Energy Particle Physics. Associate Professor, Yale University, New Haven, Conn.

Kreier, Julius P., D.V.M., Biology. Instructor, Department of Veterinary Physiology, University of Illinois, Urbana, Ill.

Kuhnley, Lyle C., M.A., Bacteriology. Student, University of Texas, Austin, Texas.

Lamb, Charles A., M.D., Cancer. Surgeon, Harvard University Medical School, Cambridge, Mass.

LaMotta, Rudolph V., M.D., Internal Medicine. Junior Research Fellow, Hartford Hospital, Hartford, Conn.

Landes, Mary Jane, A.B., Biology. Biologist, American Cyanamid Company, Pearl River, N. Y.

Langer, Alexander, M.D., Pathology. Assistant Pathologist, Harlem Hospital, New York, N. Y.

Lassetter, Edgar Lovelace, M.D., Internal Medicine. Private Practice, West Hartford, Conn.

Lavillaureix, Jean, M.D., Virology. Bacteriologist, Institut d'Hygiene, Strasbourg, France.

Lee, Harry, M.D., Internal Medicine. Clinical Instructor, Medicine, University of California Medical Center, San Francisco, Calif.

Leisten, David, M.D., Cytophysiology. Obstetrician, Brooklyn Jewish Hospital, Brooklyn, N. Y.

Lending, Miriam, M.D., Pediatric Problems. Assistant Clinical Professor, Flower Fifth Avenue Hospital, New York, N. Y.

Leonardi, Alfredo, M.D., Chemotherapy. Assistant, Institute of Pharmacology, Milan University Medical School, Milano, Italy.

Lerner, Robert, B.A., Biochemistry. Research Assistant, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

Leslie, Walter, M.D., Neurology. Head, Division of Neurology, Victoria General Hospital, Halifax, Canada.

Levin, Herman, Ph.D., Biochemistry. Research Associate, The Larkman Hospital Research Institute, Philadelphia, Pa.

Levine, Samuel A., M.D., Medicine. Internist, USAF Hospital, Eglin Air Force Base, Fla.

Lifson, Shneier, Ph.D., Polymer Physics. Senior Scientist, Weizmann Institute of Science, Rehovot, Israel.

Lindo, Frances L., B.S., Biological Sciences. Assistant Scientist, Warner-Chilcott Laboratories, Morris Plains, N. J.

Lindquist, Carl Bertil Johan, M.D., Biology. Assistant Professor, Children's Hospital, Gothenburg, Sweden.

Liu, Pearl Ming Chung, Ph.D., Biology. Teaching, Albion College, Albion, Mich.

Liu, Pinghui V., Ph.D., Medical Microbiology. Instructor, University of Louisville, Louisville, Ky.

Lockhart, Ernest E., Ph.D., Food Chemistry. Scientific Director, Coffee Brewing Institute, Hartsdale, N. Y.

Lokey, Robert Henry, M.D., Medicine. Staff Physician, U. S. Air Force Hospital, Eglin AFB, Fla.

Loney, James W., M.D., Medicine. Private Practice, Warren, Ohio.

Louria, Donald B., M.D., Infectious Disease. Research Fellow, New York Hospital, New York, N. Y.

Lowe, Norman, M.D., Pathology. Resident and Research Fellow, Pathology, DePaul Hospital, Norfolk, Va.

Luborsky, Fred E., Ph.D., Physical Chemistry. Applied Physics Group Leader, General Electric Company, West Lynn, Mass.

McCarty, Joseph Carroll, M.D., Medicine, Private Practice, Albuquerque, New Mex.

McDonald, Roderick L., M.D., Internal Medicine. Private Practice, Los Angeles, Calif.

McKeon, Clementine C., M.D., Scientific Fields Related to Psychiatry. Chief, Women's Services, Veterans Adminstration Hospital, Bedford, Mass.

MacNamee, James K., D.V.M., Veterinary Pathology. Veterinary Pathologist, Chemical Corps Biological Warfare Laboratories, Ft. Detrick, Md.

Mackrell, Thomas Nickols, M.D., Anesthesiology. Director, St. Vincent Charity Hospital, Cleveland, Ohio.

Madis, Solomon, Ph.D., Cellular Physiology. Research Associate, U. S. Vitamin Corporation, New York, N. Y.

Major, Charles W., Ph.D., Cell Metabolism. Instructor, University of Rochester School of Medicine, Rochester, N. Y.

Malcolm, Daniel, M.D., Internal Medicine. Resident, Bronx Veterans Administration Hospital, Bronx, N. Y.

Marino, Joseph V., B.S., Biophysics. Supervisor, Montefiore Hospital, Bronx, N. Y.

Markowitz, Alfred Morris, M.D., Surgery. Resident, Surgery, Presbyterian Hospital, New York, N. Y.

Mason, Aaron S., M.D., Psychiatry. Director, Veterans Administration Hospital, Brockton, Mass.

Mason, Marcus M., D.V.M., Veterinary Pathology. Director, Biologics Testing Laboratory, Worcester, Mass.

Masters, Edwin M., A.M., Tissue Culture. Teaching Assistant, University of Minnesota, Minneapolis, Minn.

Meier, Hans, D.V.M., Biology. Research Assistant, Children's Cancer Research Foundation, Boston, Mass.

Mellett, Lawrence B., Ph.D., Pharmacology. Instructor, University of Michigan Medical School, Ann Arbor, Mich.

Melton, Arthur W., Ph.D., Psychology. Professor, University of Michigan, Ann Arbor, Mich.

Michelson, Alan L., M.D., Allergy. Private Practice, Lynn, Mass.

Miller, Sherwood Perry, M.D., Medicine. Chief, Coagulation Section, City of Hope Medical Center, Duarte, Calif.

Millgate, Irvine H., Human Communications, President, Impco Inc., New Milford, N. J.

Miyagawa, Yoneji, M.D., Bacteriology. Professor Emeritus, Tokyo University, Tokyo, Japan.

Montgomery, P. O'B., M.D., Pathology. Associate Professor, University of Texas, Dallas, Texas.

Moss, Leo David, M.D., Pathology. Pathologist, Bradford Hospital, Bradford, Pa.

Mottley, Charles M., Ph.D., Biological Science. Director, Operations Research, Chas. Pfizer & Company, Brooklyn, N. Y.

Muller, Paul W., Dr.Sc., Biochemistry. Assistant Research Professor, George Washington University, Washington, D. C.

Myhre, William Norwood, M.D., Physiological Medicine. Private Practice, Spokane, Wash.

Nadel, Marvin Keith, Ph.D., Virus Multiplication. Virologist, Research Laboratories, Inc., St. Joseph, Mo.

Naito, Ryoichi, M.D., Hematology. Medical Director, The Blood Plasma Corporation of Japan, Osaka, Japan.

Nesty, Glenn A., Ph.D., Organic Chemistry. Vice-President, Allied Chemical and Dye Corporation, New York, N. Y.

Newman, David A., M.D., Cardiology. Active Staff Member, Department of Internal Medicine, Good Samaritan Hospital, Palm Beach, Fla.

Notananda, Vimol, M.B., Vector-borne Disease Control. Acting Northern Regional Malaria Control Office, Northern Region, Chiengmai, Thailand.

Olsen, Lillian R., B.S., Bacteriology. Microbiological Analyst, Staten Island, N. Y.

Ordway, Nelson Kneeland, M.D., Pediatrics. Professor, Pediatrics, Yale University School of Medicine, New Haven, Conn.

Page, James A., M.B.B.S., Neurophysiology. Staff Physician, Wyeth Laboratories, Philadelphia, Pa.

Paoletti, Alfredo, M.D., Microbiology. Assistant in Hygiene, Naples Medical School, Naples, Italy.

Paoletti, Rodolfo, M.D., Biological Applications of Radioisotopes. Assistant, Institute of Pharmacology, University of Milan, Milan, Italy.

Parshley, Philip F., M.D., Medicine. Medical Practice, West Hartford, Conn.

Paxson, Edwin W., Ph.D., Military Operations Research. Mathematician, The Rand Corporation, Santa Monica, Calif.

Pearlman, Benjamin, M.D., Internal Medicine. Assistant Professor, University of Illinois College of Medicine, Chicago, Ill.

Peets, Edwin A., M.A., Biochemistry. Research Biochemist, Lamont Geological Observatory, Palisades, N. Y.

Pegau, Lucy Byrd, M.A., Mammalian Physiology. Physical Sciences Teacher, Miss Porter's School, Farmington, Conn.

Pierce, David H., Ph.D., Teaching College Chemistry. Head, Chemistry, Asheville-Biltmore College, Asheville, N. C.

Pietryk, Helen C., B.S., Viral Immunology. Virus Research Associate, Merck Sharp & Dohme, West Point, Pa.

Pindell, Merle, H., Ph.D., Pharmacology. Senior Research Pharmacologist, Bristol Laboratories, Inc., Syracuse, N. Y.

Piro, Louis John, M.D., Neuropsychiatry. Psychiatrist, Lincoln Hall School for Boys, Lincolndale, N. Y.

Pons, Marcel W., M.S., Virology. Research Assistant, University of Michigan, Ann Arbor, Mich.

Prager, Jan Clement, M.S., Protozoology. Teaching Fellow, Biology, New York University, New York, N. Y.

Prince, James T., B.S., Virology. Instructor, University of Minnesota, Minneapolis, Minn.

Prince, John Edward, Ph.D., Cancer Research. Research Associate, The Institutum Divi Thomae Foundation, Palm Beach, Fla.

Ramirez, Ricardo, M.D., Tropical Disease. Resident, General Medicine, Cabo Romo, Puerto Rico.

Revel, Jean-Paul, Ph.D., Biochemistry. Research Fellow, Cornell University Medical College, Ithaca, N. Y.

Riley, George Joseph, M.D., Internal Medicine. Assistant Attending Physician, Samaritan Hospital, Troy, N. Y.

Risi, Joseph, D.Sc., Wood Chemistry. Professor, Organic Chemistry, Laval University, Quebec, Canada.

Roberts, Ralph C., M.D., Biology. Associate, Medicine, Northwestern University Medical School, Evanston, Ill.

Rodbard, Simon, Ph.D., Heart. Director, Chronic Disease Research Institute, University of Buffalo, Buffalo, N. Y.

Root, Maurice, T., M.D., Medicine. Practitioner of Medicine, Hartford Hospital, Hartford, Conn.

Rose, Catherine S., Ph.D., Biochemistry. Associate, Biochemistry, University of Pennsylvania, Philadelphia, Pa.

Rosenblum, Harold, M.D., Internal Medicine. Senior Associate, Mt. Zion Hospital, San Francisco, Calif.

Rosenstein, Abraham S., M.D., Medicine. Private Practice, Louisville, Ky.

Rossman, Hyman M,, M.D., Medicine. Private Practice, Oak Ridge, Tenn.

Roulston, Kenneth I., Ph.D., Geophysics. Associate Professor, Physics, University of Manitoba, Manitoba, Canada.

Russo, Richard J., M.S., Preventable Diseases. Supervisor, Poliomyelitis Vaccine Program, New Jersey State Department of Health, Trenton, N. J.

Samuels, Reuben, M.S., Civil Engineering. Engineer, Thomas Crimmins Contracting Company, New York, N. Y.

Sapir, Danile Gustave, B.A., Immunology. Medical Student, Johns Hopkins University, Baltimore, Md.

Scallet, Barrett L., Ph.D., Plant Biochemistry. Associate Director, Central Research Department, Anheuser-Busch, Inc., St. Louis, Mo.

Schleifer, Ida, M.A., Psychology. New York, N. Y.

Schmidt, Edward C. H., Jr., Ph.D., Pathology. Pathologist, Memorial Hospital, Easton, Md.

Schmitthenner, Jerry E., M.D., Cardiac Physiology. Research Fellow, Lonkenau Hospital, Philadelphia, Pa.

Schooley, John C., Ph.D., Physiology. Physiologist, University of California, Berkeley, Calif.

Schurman, Jack Vair, M.S., Chemistry. Manager, Corporate Research Department, Colgate-Palmolive Company, Jersey City, N. J.

Schwartz, Jack J., M.D., Medicine. Private Practice, Maplewood, N. J.

Schweitzer, Thomas Fred, Cytology. Student, Columbia College, New York, N. Y.

Semar, Richard W., B.S., Biology. Research Assistant, The Squibb Institute for Medical Research, New Brunswick, N. J.

Settel, Edward, M.D., Medical Geriatrics. Medical Director, Forest Hills Nursing Home and Rehabilitation Center, Forest Hills, N. Y.

Sharrett, Richard H., M.D., Gastroenterology. Resident, Internal Medicine, Veterans Administration Hospital, East Orange, N. J.

Sheffner, Leonard, Ph.D., Biochemistry. Biochemistry Group Leader, Mead Johnson Laboratories, Evansville, Ind.

Ship, Arthur George, M.D., Surgery. Resident, Surgery, Montefiore Hospital, Bronx, N. Y.

Shultz, Walter, M.S., Medicinal Chemistry. Graduate Student, Philadelphia College of Pharmacy and Sciences, Philadelphia, Pa.

Silberman, Cesar J., M.D., Gynecology-Fertility. Fellow, Clinical Research, M. Sanger Research Bureau, New York, N. Y.

Siller, Harry, Ph.D., Mathematics. Assistant Professor, Hofstra College, Hempstead, N. Y.

Silverstrini, Bruno, M.D., Pharmacology. Lepetit S.P.A., Milan, Italy.

Simonson, Herbert Mansfield, M.D., Orthopedic Surgery. Private Practice, East Orange, N. J.

Sirotnak, Francis M., Ph.D., Bacterial Nutrition. Research Associate, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

Smith, Vigo N., A.B., Physics. Supervisor, Shell Development Company, Emeryville, Calif.

Sobrero, Aquiles Jose, M.D., Gynecology, Fertility. Fellow, Clinical Research, M. Sanger Research Bureau, New York, N.Y.

Sokoloff, Vladimir P., Ph.D., Geochemistry. Consultant, Shell Oil Company, New York, N. Y.

Somlo, François, M.D., Virus. Research Assistant, University of Montreal, Montreal, Canada.

Soncin, Emilia, Dr.Pharm., Pharmacology. Department of Pharmacy, Lepetit S. P. A., Milan, Italy.

Southworth, Raymond W., Dr.Eng., Chemical Engineering. Associate Professor, Yale University, New Haven, Conn.

Sparks, Sarah Jane, M.T., Biology. Biologist, American Cyanamid Company, Pearl River, N. Y.

Speziale, A. John, Ph.D., Organic Chemistry. Research Scientist, Monsanto Chemical Company, St. Louis, Mo.

Starke, Kurt W., Dr.Phil., Nuclear and Inorganic Chemistry. Associate Professor, University of Kentucky, Lexington, Ky.

Steele, Arthur B., Ph.D., Industrial Organic Chemistry. Manager, Technical Service Department, Union Carbide Chemicals Company, New York, N. Y.

Stephens, James R., Ph.D., Organic Chemistry. Research Chemist, Standard Oil Company of Indiana, Whiting, Ind.

Stern, Walter R., M.D., Pathology. Resident Physician, Augusta, Ga.

Stevens, Eunice C., Medicine. Editor, Paul B. Hoeber, Inc., New York, N. Y.

Stevens, Rollin E., M.S., Geochemistry. Staff Associate, U. S. Geological Survey, Denver, Colo.

Stier, Paul M., Ph.D., Surface Chemistry. Group Leader, National Carbon Research Laboratories, Cleveland, Ohio.

Stock, J.J., Ph.D., General Microbiology. Assistant Professor, University of British Columbia, Vancouver, Canada.

Stone, Joseph E., Ph.D., Pharmacology. Assistant Professor, University of Arkansas Medical School, Little Rock, Ark.

Streuli, Carl A., Ph.D., Analytical Chemistry. Group Leader, Analytical Research, American Cyanamid Company, Stamford, Conn.

Stuppy, George W., Ph.D., Internal Medicine. President, Attending Staff, Presbyterian Hospital, Chicago, Ill.

Su, Helen Chien-fan, Ph.D., Chemistry. Research Chemist, The Borden Chemical Company, Philadelphia, Pa.

Sullivan, Andrew J., Jr., Ph.D., Biochemistry. Research Chemist, Campbell Soup Company, Haddonfield, N. J.

Sumsion, H. T., Ph.D., Engineering. Research Scientist, Lockheed Aircraft Corporation, Palo Alto, Calif.

Sundt, E. V., Electronic Engineering. Chairman, Board, Littlefuse, Inc., Des Plaines, Ill.

Sutherland, James Kay, M.D., Cardiology. Practicing Cardiology, Flint, Mich.

Swanson, Wilbur H., Ph.D., Microbiology. Professor, Bacteriology, San Jose State College, San Jose, Calif

Sylvestre, Emile E., B.A., Cardiology. Medical Student, University of Montreal, Montreal, Canada.

Tall, Milton G., M.D., Pediatrics. Assistant Professor, Johns Hopkins University, Baltimore, Md.

Tassoni, Ernest M., M.D., Pathology. Resident, Pathology, Temple University School of Medicine, Philadelphia, Pa.

Tatarian, Gabriel, M.D., Obstetrics and Gynecology. Assistant, Jefferson Medical College, Philadelphia, Pa.

Tausig, Fred, Ph.D., Organic and Biochemistry. Senior Chemist, Merck Sharp & Dohme Research Laboratories, Rahway, N. J.

Thesleff, Stephen, M.D., Pharmacology. Assistant Professor, University of Lund, Lund, Sweden.

Thomas, Charles W., (Rear Admiral, USCG, Ret.) A.M., Oceanography. Arctic Operations, USNC-IGY, Washington, D. C.

Thrall, Robert M., Ph.D., Mathematics. Professor, University of Michigan, Ann Arbor, Mich.

Tobey, Max, M.D., Biology. Adjunct General Practice, Beth David Hospital, New York, N. Y.

Tourkow, Lawrence P., M.D., Psychiatry. Assistant Professor, Department of Psychiatry, Wayne State University College of Medicine, Detroit, Mich.

Tovsky, Herbert M., B.S., Biology. Medical Representative, Bronx, N. Y.

Tritsch, George L., Ph.D., Biochemistry. Research Associate, The Rockefeller Institute, New York, N. Y.

Turpini, Rinaldo, M.D., Hematology. Research Fellow, St. Elizabeth's Hospital, Brighton, Mass.

Vaccari, Italo, D.V.M., Veterinary Clinical Medicine. Professor, Clinical Medicine, University of Parma, Parma, Italy.

Van Duuren, Benjamin Louis, Sc.D., Organic Chemistry. Assistant Professor, New York University-Bellevue Medical Center, New York, N. Y.

Van Eck, Edward A., Ph.D., Immunology. Instructor, Bacteriology, University of Michigan, Ann Arbor, Mich.

Van Leeuwen, Gerda, B.A., Cancer. Research Assistant, Sloan-Kettering Institute for Cancer Research, New York, N. Y.

Vernou, Eugene R., M.D., Ophthalmology. Rochester, N. Y.
Veronesi, Ricardo, M.D., Infectious Diseases. Assistant Professor, Hospital Das Clinicas, São Paulo, Brazil.
Vinson, J. William, D.Sc., Microbiology. Research Fellow, Harvard School of Public Health, Boston, Mass.
Vogel, Adolph W., M.D., Cancer. Research Staff, American Cyanamid Company, Pearl River, N. Y.
Watts, Harvey F., M.D., Medicine. Assistant Professor, Pathology, Temple University School of Medicine, Philadelphia, Pa.
Wayne, Richard S., M.A., Spectroscopy. Spectroscopist, Schering Corporation, Bloomfield, N. J.
Weber, William F., M.D., Psychology. Private Practice, New York, N. Y.
Weiner, Sylvia, M.D., Fertility and Sterility. Practicing Physician, Hartford, Conn.
Weinstein, B. Bernard, M.D., Endocrinology. Senior, Department of Gynecology, Touro Infirmary, New Orleans, La.
Weinstock, Irwin M., Ph.D., Intermediary Metabolism. Research Associate, Coler Hospital, Welfare Island, N. Y.
Weissler, Arnold Mervin, M.D., Cardiovascular Disease. Instructor, Duke University School of Medicine, Durham, N. C.
Werdegar, David, M.D., Endocrinology, Research Fellow, Medicine, The New York Hospital, New York, N. Y.
Wilber, Martin C., M.D., Biology. Assistant Head, National Naval Medical Center, Bethesda, Md.
Wilson, William L., M.D., Hematology. Associate, Medicine, Hahnemann Medical College and Hospital, Philadelphia, Pa.
Winer, Bertram M., M.D., Hypertension. Instructor, Medicine, Harvard Medical College, Cambridge, Mass.
Winklemann, R. K., Ph.D., Dermatology. Consultant, Mayo Clinic, Rochester, Minn.
Woidich, Francis de Sales, M.D., Biophysics. Research Associate, George Washington University School of Medicine, Washington, D. C.
Wolf, Benjamin, M.S., Microbiology. Assistant Instructor, School of Veterinary Medicine, University of Pennsylvania, Philadelphia, Pa.
Wolsky, Maria de Issekutz, M.D., Cytology. Instructor, Biology, Manhattanville College, Purchase, N. Y.
Wood, Ronald McFarlane, Ph.D., Microbiology. Associate Professor, Johns Hopkins Hospital, Baltimore, Md.
Yoshioka, Morimasa, M.D., Bacteriology. Research Fellow, University of Michigan, Ann Arbor, Mich.
Ziegler, Donald W., M.S., Tissue Culture. Research Associate, Wister Institute, Philadelphia, Pa.
Zimmering, Paula, Ph.D., Biochemistry. Research Associate, Francis Delafield Hospital, New York, N. Y.

## *STUDENT MEMBERSHIP*

Benincasa, Theresa, Neurophysiology. Student, Hunter College, New York, N. Y.
Colton, Robert P., B.A., Medicine. Student, New York University College of Medicine, New York, N. Y.
Elliott, Donald B., B.S., Pharmaceutical Chemistry. Instructor, St. John's College of Pharmacy, Brooklyn, N. Y.
Fagan, Sylvia Robinson, M.A., Vertebrate Paleontology. Assistant Instructor, Rutgers University, Newark, N. J.
Mandell, Arthur Aaron, B.E.E., Engineering. Electrical Engineer, Brooklyn, N. Y.
Nagler, Arnold L., M.S., Pathology. Research Fellow, Bellevue Medical Center, New York, N. Y.
Notides, Angelo, Physiology. Student, Bronx, N. Y.
O'Brian, Dennis Martin, Jr., M.S., Biology. Assistant, Fordham University, New York, N. Y.
Scheuing, Marilyn R., M.A., Regeneration Studies in Vertebrates. Medical Student State Medical College, Brooklyn, N. Y.
Schwab, John R., A.B., Therapy and Research in Clinical Psychology. Graduate Student, Adelphi College, Garden City, N. Y.

Seligman, Gilbert Kalin, Medicine. Student, Columbia University, New York, N. Y.
Sohn, Loretta, Physiology. Jamaica, N. Y.
Zelman, Jerry, B.A., Medicine. Student, New York, N. Y.
Zuntag, Frances Marion, Physiology. Student, Hunter College, New York, N. Y.